Getting Ready for Bovine Somatotropin

C. E. Coppock
Texas A&M University and
The Texas Agricultural Experiment Station

Introduction

One may be certain that future technology will bring developments incomprehensible today. Yet, it is unlikely that any will refute or even modify the laws of thermodynamics. In other words, we'll have to pay for increased milk yields with corresponding nutrients including energy. Yet the synthesis of milk from feed ingredients will become much more efficient regardless of how we choose to define that word. With high genetic merit for milk pervasive in our dairy cow population, continued advances in the engineering of milking systems, more effective control of mammary infections, and dramatic advances in repartitioning agents, all these have combined to focus attention on nutritional constraints to higher, but economic yields of milk. Although the effects of most future technology on nutrition programs are not directly predictable now, the effects of exogenous bovine somatotropin (BST) are well established because of the large amount of research already published concerning the responses of cows given this product. Therefore, in contrast to most previous technologies, it is possible to prepare for the arrival of this technology even before it becomes available. The central theme of this paper is that preparation for the arrival of BST can pay off as soon as that preparation begins; it can payoff even if BST is never approved; it can payoff for those who choose not to use BST.

My objectives in this paper are to note briefly how cows respond to BST and then describe the way these responses should direct one's preparation for the arrival of this new technology.

How Do Cows Respond to BST?

To deal with the effect of a new technology, one should know how the new technology works. Assuming the new technology has a positive effect on production, how is that increase in yield brought about? How does the cow respond to this new technology? 1) Increased genetic merit may occur with new technology such as embryo splitting, embryo sexing, and semen sexing as well as use of genetically superior sires. This technology will cause greater production accompanied by greater intake of feed. 2) Other technology may result in a greater consumption of feed energy. An example of this is in the use of high fat ingredients and rumen inert fat products. 3) Other technology may increase the digestibility of feed. An example of old technology to increase digestibility of forage is early cutting--a technology just as relevant today and for the foreseeable future. 4) Other technology might decrease the heat used in metabolizing nutrients for milk synthesis. Supplemental fats do this in pigs, and probably the same effect occurs in cows. 5) Another technology, 3X milking, directs more feed energy toward milk synthesis with a small increase in feed intake. But how do cows respond to BST?

The most obvious response of cows given BST is a sharp increase in milk yield. Studies of total energy balance with respiration chambers at USDA-Beltsville (Tyrrell et al., 1982) revealed that neither digestive nor metabolic efficiency was changed significantly when lactating cows were injected with BST. So the explanation for the increased yields is that BST enables the mammary gland to command a high priority for nutrients from both the diet, and in early lactation, from body reserves (Figure 1). The small depression in feed eaten seen in the short-term studies was of concern because with no change in digestive or metabolic efficiency, the increase in milk yield could not be sustained unless feed intake also increased.

Responses observed in long-term studies show that the large increases (16 to 36%) in milk energy seen in short trials were sustained, but increases in feed intake of 3 to 15% also became evident. In several studies, however, the increased feed intake was not enough to provide the energy for the increase in milk energy produced. This means that many of the cows probably finished the long-term studies with lower body energy reserves than when they began, or lower reserves than the control cows in the same study. This point can be seen in data from Minnesota (Soderholm et al., 1986). At 25 mg/day of BST, the increase in feed (4.84 lb) provided enough energy for 11.9 lb of 3.5% FCM, but 19.1 lb were obtained. Fortunately, these workers measured body fat, body condition score, and body weights which permit verification of the assumptions based upon milk and feed energy increases. Body weights did not differ significantly, but both body fat and body condition score were significantly lower for cows that received BST. Dairymen are astute evaluators of body condition and know that cows who have not regained body condition by the end of lactation, must do so to continue another lactation successfully. But body condition can be restored during lactation when cows receive BST as shown in one complete lactation study at Cornell (Bauman et al., 1985). Moreover, this feature is largely under managerial control in the form of the decision point at which cows are moved from high to medium to low dietary nutrient densities. This decision should be based primarily on restoration of body condition. To summarize the responses of lactating cows to BST: a) in early lactation, BST increases the nutrient flow from body reserves to milk synthesis; b) it increases feed intake, but only after a lag of 3-4 weeks; and c) it increases heat production.

Now that we understand how cows respond to BST, one might ask, which systems of dairy cattle management will be affected? How can one strengthen those systems in preparation for BST?

Integrated Systems in Dairy Cattle Management

Several years ago entomologists developed a strategem for dealing with insect pests, a comprehensive program they called "Integrated Pest Management Systems (IPMS)". According to Webster's New Collegiate Dictionary, "integrate" means, "to form, coordinate, or blend into a functioning or unified whole: unite". More recently, reproductive physiologists adopted the concept as in "Integrated Reproductive Management Systems (IRMS)". At the dairy short course in Texas in 1987, Dr. David

Beede (1987) introduced to us the concept of Integrated Environmental Management Systems (IEMS). In this paper I will introduce the concept of "Integrated Nutritional Management Systems (INMS)", which I define, in the context of dairy cattle, as the process of integrating the a) procurement, b) ingredient evaluation, c) inventory-storage, processing, e) formulation, f) feeding system, and g) on-the-farm delivery of diets, that will sustain high yields economically in dairy cattle production.

Procurement. In this category, I include, a) writing specifications, b) forward contracting, c) hedging, d) delivery, and e) quality control (QC) of incoming ingredients. The importance of sound financial advice concerning forward contracting, hedging and purchasing in quantity, is crucial. Smaller dairies may combine to purchase in carload lots, but the minimum tonnage which one should be able to receive at once would be one large bulk truck load. But purchasing directly from producers or through a broker, may place the quality control responsibility on the purchaser, the dairyman. Without previous experience, this may result in the acceptance of inferior grades of commodities. Lane (1986) recently made some appropriate suggestions for QC at the farm when receiving commodities: a) always have someone meet the truckload of incoming product; b) before unloading, sample and inspect the commodity noting its appearance, smell, taste, touch, tag, take a sample, and split the sample with the driver; c) keep a daily log noting the day of delivery, the source, the guarantee, the trucker and the observations made in b) including a sample identification code; d) use your scales or an independent one nearby; e) run a moisture test as soon as possible; f) have any nutrient analyses run by an independent lab with a copy sent by the lab to the seller. The specifications and guarantees for a purchase contract are usually written by a purchasing agent or other officers of a feed company. Examples of these specifications and guarantees will be very helpful to those with little experience in this subject.

Ingredient evaluation. This concept includes much more than a laboratory test as noted under b) in the previous paragraph. But, it is essential to find the services of a feed testing laboratory that is both accurate and fast. Not only will one need to test purchased ingredients, but also it is essential to confirm the formulations that are prepared on the dairy, especially, the final total mixed ration (TMR).

Inventory costs and storage losses. These are important components of the INMS. These may be overlooked, but to obtain total costs, these must be included.

Processing. Many commodities (sometimes called by-products) need no processing, but feed grains should be rolled or fractured. Whole linted cottonseed needs no processing because less than 1% of the whole seeds passed through the cow (Coppock et al., 1985). But in the same study, more than 11% of whole acid-delinted seeds passed through the cow undigested.

Formulation. All formulation should begin with intensive and comprehensive forage and feed testing. The case for forage testing has been presented on many occasions. Recently, it was emphasized by Bertrand

and Ely (1987), who showed that in crude protein (CP) percentage, forages from ten Georgia farms ranged from 5.1 to 15.5% for corn silage, 5.8 to 12.6% for sorghum silage, and 15.4 to 25.3% for alfalfa. Great variation and uncertainty are the reasons book value cannot be used for precise formulations. One should expect greater nutrient variation in many of the by-products than in feed grains.

In formulation one should consider predicted dry matter intake, net energy for lactation (NE_l), crude protein, plus a specific fraction of undegraded and degraded protein, one of the newer fiber fractions, ADF or NDF, fat, 7 macro and 7 micro elements, vitamins A, D and E, niacin, buffering capacity, and in some cases, water composition. It is very likely that a nutritional constraint that limits production in a herd before use of BST, will be more devastating following use of BST.

Comprehensive formulation based upon detailed forage and feed testing with the intended nutrient profile confirmed in the final mixture will do much to avoid dietary deficiencies. These deficiencies will eventually depress production, but earlier they may increase heat production. Reid (1972) identified protein, phosphorus, and possibly sodium, magnesium, cobalt, and copper as being in this group. Earlier, Kleiber (1945) noted that most mineral elements and vitamin E deficiencies increase the metabolic rate which lowers energy efficiency.

Dry cow care and management should include a careful monitor of body condition so that reserves can be replenished if this has not been done during late lactation when it is more efficient. Only if the prepartum cow has been prepared for the stress of a new lactation can she respond to the demand high yields will make upon her. The cow in negative energy flow (NEF) requires special consideration in formulation because the large reserve of energy is probably unmatched by any other nutrients with the possible exception of calcium. In effect, the cow in NEF needs a diet enriched in all nutrients, relative to the cow who can eat enough feed to meet her energy requirements. Supplemental fat or ingredients with high fat should be a component of diets of cows in NEF which allows greater energy consumption without the adverse effects of excess starch and too little fiber. The study of Schneider and others (1987) showed that cows that received both BST and calcium salts of long chain fatty acids produced more during 4-wk postpartum than cows receiving only 1 of the 2 treatments. Use of BST appears to make cows of all genetic abilities better cows that produce more and that require correspondingly more nutrients.

In addition, to increasing energy density, a special feature of added fats is their reduction in heat increment. Early work at Penn State showed that with equicaloric diets, increasing fat decreased heat increment, making more calories available for production but also reducing heat stress in hot weather. This work was done with rats and it is not certain it applies to ruminants. However, Moody (1962) observed lower body temperatures in cows fed whole cottonseed (WCS) during heat stress in Arizona. More recently, Kronfeld et al. (1980) fed protected tallow to Holsteins 2 to 16 wk postpartum which provided 25% of the ME as fat. Protected tallow increased milk fat yield 12.4% and calculations of improved metabolic efficiency favored cows fed protected tallow with a peak of 87.5%. Chalupa (1982) noted that higher metabolic efficiencies with long chain fatty acids reflect the higher efficiencies with which ruminants are able to use these acids compared to the volatile fatty acids.

An increased efficiency suggests added fat would be more valuable in hot weather than in cold weather. Feeding whole cottonseed (WCS) increases the transfer of dietary long chain fatty acids to milk fat (Smith et al., 1981) and the calcium soaps of long chain fatty acids have been shown to provide beneficial effects of increased dietary energy density without adverse effects on rumen digestibility. Because WCS appears to be a slow release (in the rumen) of oil, one could predict that WCS and calcium soaps have additive effects on the nutrition of the lactating cow.

Feeding Systems. The complete ration or total mixed ration (TMR) fed ad libitum has much to commend it as a system to feed dairy cows. Specifically, it's easy to transfer cows from the low energy prepartum diet to the postpartum high energy diet with a minimum probability of digestive upsets. Dilution of the concentrate with forage and ad libitum feeding results in many small meals through the day with a stable rumen fermentation even with high starch ingredients. For those dairymen who feed concentrate separate from forage, the computer-controlled concentrate feeders have much to offer. They distribute the concentrate in small amounts and allow a monitor of the amount and pattern of consumption. For those who pasture the milking herd and the TMR is not feasible, the computer-controlled feeder is especially beneficial. But it contains within its application, one significant limitation; the prediction of the forage eaten by an individual cow is not known, so neither is the contribution of the forage or the total nutrient intake precisely defined.

On-the-Farm Delivery. There are also economies to be made in transportation and feed handling on the farm. A survey of corral feeding and energy used for feed distribution by 175 herds in Tulare County, California in the summer of 1980 (Schultz, 1981) shows large herd sizes, all fed some hay, and the larger herds were fed more on-the-farm grain mixtures (Table 1). The average daily fuel and labor cost per 100 milking cows shows a fuel cost advantage for separate feeding in 3 smaller herd categories but a lower fuel cost for total mixed rations in larger herd categories. Dairies of similar size were often greatly divergent with respect to amount of fuel and labor needed to feed their herds. Some were adept at locating feed ingredients at efficient points, in matching equipment size to specific needs, and at conserving energy through innovation and attention to details.

Chilled Drinking Water. Our work with chilled drinking water for lactating dairy cows under heat stress has been consistent (Lanham et al., 1986; Baker et al., 1988; and Wilks et al., 1989) in showing reduced respiration rates and body temperatures, increased feed dry matter intakes, and greater milk yields. However, the cost effectiveness of this technology has not been clearly evident to us. We used a refrigeration system provided by agricultural engineers which had been built to chill meat in previous research. Our calculations showed that the economic return using this small unit would be marginal with the production responses that we had achieved. Recent conversations, however, with a representative of a major milk cooling equipment company revealed that his calculations showed that one pound of milk would pay for chilling water 20^{o}F for lactating cows in the summer. If this is the case, this technology has wide application, especially in the southern and eastern states. Although evaporative cooling systems have been designed and shown to be economically effective in low humidity areas, especially in Arizona, we have assumed that evaporative cooling would be much less effective in areas of high humidity. Chilled drinking water is effective independent of relative humidity. Although we have not addressed these areas in our research, over long periods of time, reproductive efficiency, mastitis, and longevity may also receive benefits from chilled drinking water. It is clear now, that dairymen who are fortunate to have cold well water should not bring that cold water up to an open trough where it will warm up, but they should keep it shaded, or better, use one of the newer insulated tanks to keep it cold until the cows drink it.

Management Diagnostics

Analysis and evaluation of herd management constraints which currently limit milk yields will be valuable to increase the probability of success with BST. For instance, use of BST under conditions where the diet is qualitatively incomplete might induce a more severe manifestation of the nutrient deficiency than is seen without BST. A Georgia study evaluated management practices used by 2712 southern dairy farmers and showed that those who used forage testing and ration balancing had herd averages 693 lb/cow/yr greater than those who did not (Ely and Smith, 1986). A demonstration project on nutrition and forage quality in Maryland showed that participants saved an average of \$.20/cow/day in feed costs and a production response was achieved in 20 of 28 herds (Cassell and Vough, 1987). Herd managers who do not test their forages and practice feed programming will be less likely to see the potential possible with BST.

Summary and Conclusions

BST causes cows to give more milk, to eat more feed, and to produce more heat. Management systems which encompass nutrition and environment will be directly affected. Improvement in these systems will help to insure the success of BST use. But improvement in these systems can be profitable without BST.

Why not use the impending arrival of BST as the impetus, the incentive, the motivation to make those changes in your management that you intended to make last year, but just didn't get around to it?

Does it really matter whether BST is approved in September, October, or November, or January, February, or March. Today is May. Now is the time to begin the preparation that will make BST pay for you.

Selected References

Baker, C. C., C. E. Coppock, J. K. Lanham, D. H. Nave, and J. M. LaBore. 1988. Chilled drinking water effects on lactating Holstein cows in summer. J. Dairy Sci. 71:2699.

Bauman, D.E., P. J. Eppard, M. J. DeGeeter, and G. M. Lanza. 1985. Responses of high-producing dairy cows to long-term treatment with pituitary somatotropin and recombinant somatotropin. J. Dairy Sci. 698:1352.

Beede, D. K., D. R. Bray, R. A. Bucklin, F. Elvinger, and J. K. Shearer. 1987. Integrated cooling systems for dairies in hot humid environments. p. 5 in Proc. Dairy Shortcourse, TX Agr. Ext. Ser., College Station.

Bertrand, J. A., and L. O. Ely. 1987. Corn silage protein ranged from 5 to 15 percent. Hoard's Dairyman 132:629.

Cassell, E. K., and L. R. Vough. 1987. Maryland dairy herd demonstration project III. Changes in nutrition and forage quality. J. Dairy Sci. 70(Suppl. 1):168. (Abstr.)

Chalupa, W. 1982. Dietary fat for lactating dairy cows. Feed Mgt. 33:(10):39.

Coppock, C. E., J. R. Moya, J. W. West, D. H. Nave, J. M. LaBore, and C. E. Gates. 1985. Effect of lint on whole cottonseed passage and digestibility and diet choice on intake of whole cottonseed by Holstein cows. J. Dairy Sci. 68:1198.

Ely, L. O., and J. W. Smith. 1986. An interactive managerial checklist for the dairy farmer. J. Dairy Sci. 69(Suppl. 1):122. (Abstr.)

Kleiber, M. 45. Dietary deficiencies and energy metabolism. Nutr. Abstr. & Revs. 15:207.

Kronfeld, D. S., S. Donoghue, J. M. Naylor, K. Johnson, C. A. Bradley. 1980. Metabolic effects of feeding protected tallow to dairy cows. J. Dairy Sci. 63:545.

Lanham, J. K., C. E. Coppock, K. Z. Milam, J. M. LaBore, D. H. Nave, R. A. Stermer, and C. F. Brasington. 1986. Effects of drinking water temperature on physiological responses of lactating Holstein cows in summer. J. Dairy Sci. 69:1004.

Lane, A. G. 1986. Quality of commodities. Paper pres. at the Texas Grain & Feed Seminar, Nov. 4, Irving, TX.

Moody, E. G. 1962. Whole cottonseed in dairy rations. 11th Ann. Dairymen's Conf., AZ State Univ., Tempe.

Reid, J. T. 1972. Some feeding fundamentals. Unpublished mimeo, Cornell Univ.

Schneider, P. L., B. Vecchiarelli, and W. Chalupa. 1987. Bovine somatotropin and ruminally inert fat in early lactation. J. Dairy Sci. 70 (Suppl. 1):177. (Abstr.)

Schultz, T. 1981. Corral feeding and energy costs. p. 1 in 12th Ann. California Dairy Cattle Day.

Soderholm, C. G., D. E. Otterby, F. R. Ehle, J. G. Linn, W. P. Hansen, and R. J. Annexstad. 1986. Effects of different doses of recombinant bovine somatotropin (rbSTH) on milk production, body composition, and condition score in lactating cows. J. Dairy Sci. 69 (Suppl. 1):152. (Abstr.)

Smith, N. E., L. S. Collar, D. L. Bath, W. L. Dunkley, and A. A. Franke. 1981. Digestibility and effects of whole cottonseed fed to lactating cows. J. Dairy Sci. 64:2209.

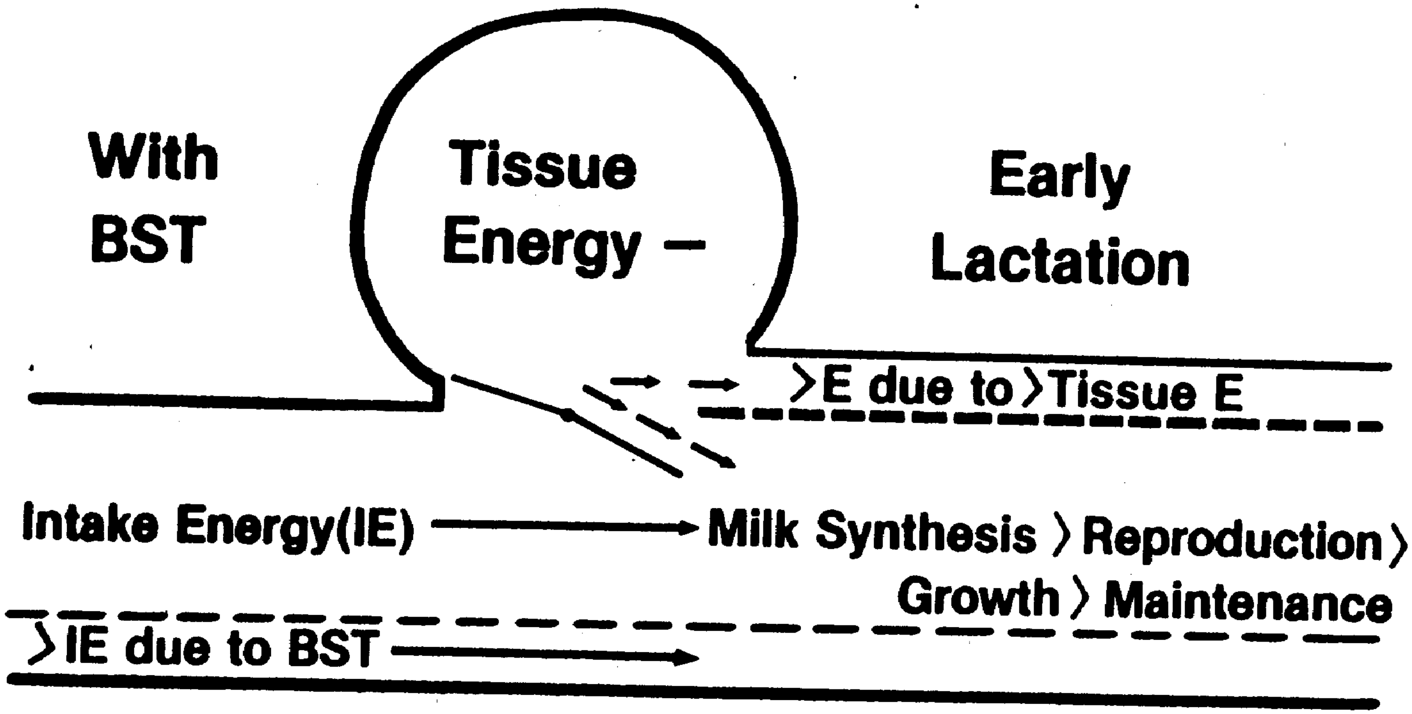
Tyrrell, H. F., A. C. G. Brown, P. J. Reynolds, and G. L. Haaland. 1982. Effect of growth hormone on utilization of energy by lactating Holstein cows. Proc. EAAP Symp. on Energy Metabl., p. 10.

Wilks, D. L., C. E. Coppock, J. K. Lanham, K. N. Brooks, C. C. Baker, R. G. Elmore, W. L. Bryson, and R. A. Stermer. 1988. Responses of lactating Holstein cows to chilled drinking water in high ambient temperatures. J. Dairy Sci. 71 (Suppl. 1):212. (Abstr.)

Table 1. Tulare county dairy corral feeding practices.[1]

Herd Size	Herds	Average Cows Milking	Production Strings	Corral Grain %		Grain Mix %		Roughage Used %			Cost/100 milking cows			
											Fuel $		Labor Minutes	
				Separate	Complete	Commercial	On-Farm	Hay	H+Silage	H+Green	Separate	Complete	Separate	Complete
0- 200	35	125	1 - 2	38	0	99	1	80	20	0	.80	--	55	--
200- 400	79	253	2 - 3	57	3	46	54	42	55	3	.85	1.15	60	90
400- 600	65	426	3 - 4	59	19	32	68	20	68	12	1.10	1.65	50	60
600- 800	21	575	3 - 4	80	10	11	89	0	100	0	1.30	0.80	40	40
800-1000	15	705	4 - 5	70	30	30	70	10	60	30	1.10	0.95	40	45
1000-2000	18	1130	4 - 6	67	33	8	92	34	58	8	2.50	1.50	50	50

[1] from Shultz (1981).



With
BST
Tissue
Energy –
Early
Lactation
>E due to>Tissue E
Intake Energy(IE)
Milk Synthesis > Reproduction >
Growth > Maintenance
>IE due to BST