THE USE OF NUTRITION MODELS IN THE COMMERCIAL FEED INDUSTRY

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Nutrition models have specific application and use in the commercial feed industry by serving as tools for: 1) formulating more precise animal diets, 2) designing feeding recommendations, 3) instructing and educating technical and field staff, 4) defining and developing research priorities and 5) trouble-shooting and problem-solving for feed clientele. The Cornell Net Carbohydrate and Protein Model (Fox et al., 1991) will be reviewed and specific examples will be presented to support applications in the commercial feed industry.

MODEL DESCRIPTION AND TERMINOLOGY

The Cornell Net Protein and Carbohydrate System (CNCPS) is a dynamic whole-animal nutrition computer model developed to improve the prediction of dairy and beef cattle performance (milk yield, changes in body condition, weight gain) under various, environmental, feedstuff, and management conditions. The CNCPS is the result of efforts by many scientists over a period of several years. The CNCPS consists of sub-models(1,2,3,4,5) which interactively communicate to allow precise analysis of the animal(s) under evaluation. The purpose of this paper is to provide application and use of the CNCPS as it applies to the commercial feed industry.

Modeling is a technique to apply and extend a system approach to a complex problem or object(6). Model building involves intuition, imagination and skill based upon the application and extension of biological principles(7). Model validation or the agreement of model behavior with real system behavior is essential in the application of the model to the problem(8). Integrated system models have become more prevalent with the advent of the inexpensive, and rapid microprocessor; however, few models have utilized a systems modeling approach as used in the CNCPS.

THE BASIS FOR USE OF DYNAMIC COMPUTER MODELS

Dynamic computer nutrition models provide assimilation and quantification of a vast amount of nutrition and feeding information. They also provide input for refining feeding formulations by more precisely defining cattle nutrient requirements. However, these provisions do not preclude the need for highly skilled and trained nutritionists.

Integration of Information

The U.S. feed manufacturing industry is a dynamic industry encompassing changes and integrating technology from developments in nutrition, feed/forage analysis, feeding management and many other areas of science. A vast wealth of information exists in each of these areas which has increased our awareness and need to integrate this information into a system for utilization.

Dynamic Nutrient Requirements

Current National Research Council dairy(9) and beef(10) nutrient requirements are based upon static values which makes it difficult to predict nutrient requirements and cattle performance beyond standardized conditions. Educated guesses can provide for satisfactory performance but results are extremely variable depending upon the appraiser. Higher animal productivity will demand more precise nutrient requirement values because the margin for error in ration formulations is reduced and the economic loss of an "educated guess" can be tremendous. Quantifying the impact of environment, management, and animal variation on cattle nutrient requirements is critical in achieving optimal performance. This demands a system to account for the variation in all inputs affecting cattle performance.

Specialized Formulations

The animal feeding industry is maturing and is becoming more segmented(11). As a result, producers are demanding more precise, customized feed formulations that optimize return on investment and income over feed cost. Evidence of more precise formulations of ruminant rations is seen in the balance of protein and carbohydrate fractions where at one time, only the crude protein and energy were balanced. Additionally, larger production units have resulted in feed manufacturers formulating diets for specific production units. Nutrition models can provide valuable input for design of customized feed formulations and recommendations for specific production units as has been suggested by Black et al.(12) in the formulation of swine feeds.

Elevated Services

The U.S. commercial feed industry is becoming more of a service-oriented, value-added, nutrition management input that will market "nutrients" rather than simply being a supplier of tons of feed(11,13). Nutrition models can be a valuable supplement to an effective service program. However, nutrition models alone are not the answer as elevated service levels require the skills of highly trained and educated individuals(13). Therefore the U.S. feed industry must have managers who have the vision to employ technically trained, motivated individuals with a keen level of interpersonal skills to effectively fill this role. A nutrition model such as the CNCPS supplements the skilled individuals ability to formulate specialized diets, trouble-shoot and diagnose farm problems, design specific feeding recommendations, and educate field staff/clientele.

EDUCATIONAL ROLE

The CNCPS is a valuable educational and instructive tool. As the feed industry moves more toward a service orientation, education and transfer of information to the producer will play a more critical role in maintaining customer satisfaction(13,14). Therefore, it will be imperative for the individual feed manufacturer to have an on-going intensive technical training of their field staff. Likewise, extension agents and nutrition consultants will need to stay abreast of new technology. The CNCPS is designed and is being used as a instructional tool in the graduate and undergraduate teaching program at Cornell University. The major instructive role of the CNCPS is in the interactive use by feed consultants, nutritionists, producers, and other students of nutrition. Biological principles taught in a class room or observed in the field are reinforced by quantification through use with the CNCPS.

An example is considered which reinforces the quantification of biological principles. A dairyman may have a difficult time justifying the cost of feeding replacement heifers additional grain when housed in open lots in the winter season. The difficulty arises when the dairyman is not able to visualize the elevated maintenance energy requirement in the winter. The CNCPS quantifies the effect of a cold environment and predicts an adjusted rate of gain. Quantification of weight gain can be a valuable tool for educating producers on the effects that feeding and housing can have on replacement heifer growth (Table 1).

Table 1: Quantification of Heifer[1] Growth under Various Environment and Feeding Scenarios as Predicted using the CNCPS.

	A	B	C	D	E
Season-->	Summer	Winter	Winter	Winter	Winter
Ration-->	Pasture (Ex.Mgmt)	Hay 1# Grain	Hay 5# Grain	Hay 1# Grain	Hay 5# Grain
Housing->	None	None	None	Inside	Inside
Coat --> Condition	Dry/Clean	Wet/Mud	Wet/Mud	Dry/Clean	Dry/Clean
Predicted Gain --> (CNCPS)	1.6	.8	1.3	1.1	1.8

1) 750 lb. body weight, 14 months of age, no feed additives.

We currently have a two-day training program designed for industry nutritionists, feed consultants, and extension personnel to become familiar with the use of the CNCPS. Several groups have attended the training program and found it to be very useful in not only usage of the CNCPS but also learning and applying nutritional principles. Interested persons or groups are invited to contact Cornell University, Department of Animal Science for details. The correct use of the CNCPS assumes a background in Lotus-1-2-3 spreadsheet usage, a basic nutrition understanding, and a knowledge of the limitations within the program. Knowledge of the limitations is essential to allow proper application of model output. Validation to date of the CNCPS has revealed good agreement with research results(5). Further validation is required to ensure accuracy in all aspects of the model output.

RESEARCH

Nutrition models can have a valuable input in support of research programs by identifying areas of incomplete knowledge or extending our current understanding of biology. Baldwin(15) has suggested questions for areas where models are useful in identifying and evaluating specific metabolic concepts and research results. Models can provide insight into questions, such as:

1) Does this new concept or result make sense as it relates to the whole animal?
2) Does this new concept or experimental result lend insight into further description of current understanding?
3) What additional experiments are needed to further explain our current understanding?

4) What should be the priority in the sequence of experiments that are identified?

Some examples of nutrition models developed for evaluating specific research questions include: the evaluation of feed nutritive value(16), measurement of energetic efficiency(17), and quantification of intestinal amino acid flow(18). The CNCPS utilizes a more aggregated modeling concept (whole animal) as it applies to nutritional diagnostics and ration formulation and is more applicable for directing applied research than specific metabolic programs. The current CNCPS has been aggregated to the level of inputs at the farm level, but the CNCPS has been and is being utilized to provide input into designing and interpreting experiments and prioritizing research programs at Cornell.

Several critical experiments have been identified by researchers at Cornell which will enhance our understanding and improve the prediction of the CNCPS model. These experiments include: (not in order of priority) development of a pH sensitive rumen sub-model, refinement of the effective dietary fiber requirements, development of a VFA rumen sub-model, refinement of metabolic transfer coefficients for amino acids, field evaluation and accuracy of current model outputs, validation and refinement of intake and energy balance prediction, and validation and refinement of heifer growth.

FEED FORMULATION

Current feed formulations are based upon static nutrient requirements for cattle under no-stress conditions. However, cattle vary in type and are fed in nearly every climatic and environmental extreme that exists in the United States. In addition, variations in management and feed quality are extremely diverse. Thus we apply requirements determined under standardized conditions and generalized feed analysis to an infinite combination of animal, management, and environmental situations. The CNCPS accounts for variations in animal, management and environmental extremes and adjusts the production level to reflect the adjustments in the nutrient requirements. It can therefore be used as a valuable input for defining precise nutrient requirements in formulating customized rations.

Accurate feed formulations also depends upon accurate analysis of feedstuffs. Methodology for measurement of individual feedstuff degradable protein and energy content is very research intensive and values are often not available. Degradability of a feed protein is characteristic of not only the feed protein but also feed particle size and ruminal passage rate. Additionally, metabolizable energy content of a feed is variable depending upon rumen retention time, especially for fibrous feeds. A sub-model developed by Chalupa(18) is utilized within the CNCPS and generates variable degradabilities of protein for individual feedstuffs. Variable degradabilities of protein and carbohydrate are calculated in the CNCPS (Table 2). These variable protein degradability values can provide input to an LP matrix for formulating line feeds for groups of farms under similar management, environment, and animal conditions or for a individual farm condition.

Future advancements which will have an affect on accuracy of formulation accuracy include: 1) more accurate predictions of dry matter intake, 2) refinements in nutrients requirements (specifically amino acids), and 3) more accurate and refined methodology of feedstuff analysis.

Table 2: Rumen Degraded Protein and Rumen Degraded Non-Structural Carbohydrate of 4 Feeds as Based on Prediction From the CNCPS Model[1]

		Dry Matter Intake (% of BW)		
		2.8%	3.5%	4.2%
Corn Silage	R Deg Protein[2]	74.2	72.7	71.3
	R Deg NSC[3]	89.8	87.9	86.1
Soybean Meal 49	R Deg Protein[2]	67.2	63.8	60.9
	R Deg NSC[3]	84.1	81.2	78.5
Dry Brewers Grain	R Deg Protein[2]	37.1	33.7	31.1
	R Deg NSC[3]	88.5	86.2	84.1
Wheat Midds	R Deg Protein[2]	78.2	75.4	73.1
	R Deg NSC[3]	89.2	87.1	85.0

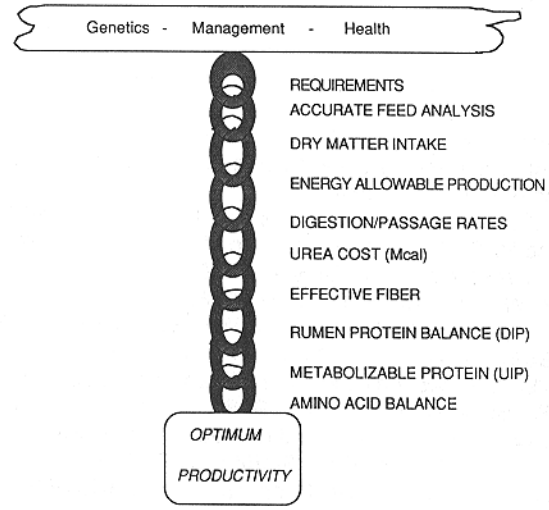
1) 1320 lb BW.,Forage Avg. Length Cut,Ingredient analysis as listed in (5).
2) % of Ingredient Crude Protein
3) % of Ingredient NSC

NUTRITIONAL DIAGNOSIS

Diagnosing cattle performance begins with determining if the observed performance is optimal under the current animal, environmental, management, and feeding conditions. In the past, individual estimates or "best guesses" have been relied upon to describe suboptimal cattle performance and these estimates have been used to give our best judgment as to the cause of lower than expected performance when conditions were different than "average." This best guess system was highly variable depending upon the appraiser and difficult to quantify. The CNCPS is based upon a hierarchal diagnostic framework to provide quantification of factors which affect performance. A systematic diagnosis such as presented here does not guarantee a successful diagnosis but should increase the appraisers proficiency in identifying the "weak link," and reduce the time required to identify the problem. Overall this should result in an awareness on the part of the client-producer of better service and lead to elevated customer loyalty.

The nutritional diagnostic framework used in the CNCPS to achieve optimal production is based upon a solid foundation of well-managed, healthy, and genetically-sound cows. The diagnostic steps used in the CNCPS (Figure 1) follow the steps of: 1) quantification of animal and environmental factors affecting nutrient requirements, 2) accurate feedstuff analysis, 3) accurate dry matter intake, 4) quantification of energy allowable production, 5) account for effects of digestion and passage rates, 6) review the energy cost of urea synthesis, 7) maximize rumen function by maintaining effective fiber intake, 8) balance rumen ammonia and peptides, 9) balance metabolizable protein requirement with undegraded protein, and 10) review and balance essential amino acid profiles.

Figure 1: NUTRITIONAL "WEAK LINK" ANALYSIS



CONCLUSION

Although currently in infancy for the commercial feed industry, integrated computerized nutrition models are in our nutrition future as tools for 1) integrating and applying the vast wealth of nutrition and feeding information which exists, 2) defining nutrient requirements for variations in animal, environment, and management, 3) formulating more precise and customized feed rations, and 4) supplementing extended nutritional service programs.

The Cornell Net Carbohydrate and Protein System has direct application to the commercial feed industry as a valuable instructional tool for educating nutritionists and field staff, a key input in evaluating research concepts and identifying critical experiments, a supplement to current ration formulation schemes by providing precise feed protein degradability and energy values, a quantification for adjustment in nutrient requirements for specific groups of cattle and a key diagnostic instrument in diagnosing client-customer problems and optimizing cattle productivity.

The CNCPS software program is available as a LOTUS 1-2-3 spreadsheet for use on IBM and compatible computers with a minimum of 640K. Copies of the documentation, user's guide(5) and software are available for purchase by contacting Gloria Smith, 130 Morrison Hall, Cornell University, Ithaca, NY 14853.

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