

Improving the professionalism of Wisconsin county Extension faculty through use of forage analyses and computer ration formulation programs

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Use of forage analyses and the three dairy diet formulation programs has assisted Wisconsin dairy farmers to make greater progress toward highly competitive, profitable dairying. Acid-detergent fibre (ADF) has proven very satisfactory in predicting forage energy value. The equation to predict digestible dry matter ($DDM = 88,9 - 0,779 \cdot ADF$) has been in use for over 2 years and has been well accepted as an estimate of net energy-lactation or TDN for dairy diets. Neutral-detergent fibre (NDF) has been incorporated into the Badger Balancer (BB) and Total Mixed Ration (TMR) formulation programs with increased farmer satisfaction and animal performance when feeding the resulting diets. Use of 21% NDF from forage in the total diet dry matter has worked well to specify minimum forage in the milking cow diet. Using NDF to specify maximum forage in lactating cow diets has simplified dairy diet formulation. When using NDF to specify maximum forage, one must no longer use rule of thumb or other arbitrary limits to limit the contribution from low ADF and high NDF forages such as corn silage and grasses.

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Die gebruik van voeranalises en die drie suiweldieetformuleringsprogramme het Wisconsin se suiwelboere gehelp om groter vooruitgang te maak ten opsigte van hoogs kompeterende, winsgewende suiwelboerdery. Gedetergeerde suuronoplosbare vesel (SVV) was baie bevredigend vir die voorspelling van die energiewaarde van voer. Die vergelyking om verteerbare droëmateriaal te voorspel ($VDM = 88,9 - 0,799 \cdot SVV$) is reeds meer as 2 jaar in gebruik en word aanvaar as 'n goeie beraming van totale energie-laktasie of TVV vir melkkoeie. Gedetergeerde neutraal onoplosbare vesel (NVV) is in die 'Badger Balancer' (BB)- en 'Total Mixed Ration' (TMR)-formuleringsprogramme ingebring met toenemende tevredenheid van die boere en toenemende prestatie by die diere met die voer van die geformuleerde diëte. Die gebruik van 21% NVV vanaf voer as deel van die totale droëmateriaal het goed gewerk om die minimum hoeveelheid ruvoer vir 'n melkkoei-dieet te spesifiseer. Die gebruik van NVV om die maksimum hoeveelheid ruvoer in die dieet van lakterende koeie te spesifiseer is vereenvoudig deur die suiweldieetformulering. Wanneer NVV gebruik word om die maksimum hoeveelheid ruvoer te spesifiseer, moet daar nie ander arbitrêre reëls en beperkings gebruik word om die bydrae van lae-SVV- en hoë-NVV-voere soos mieliekuilvoer en grasse te beperk nie.

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Introduction

The Cooperative Extension Service (CES) in Wisconsin expects county faculty to provide quality subject matter expertise to clientele. Wisconsin county CES faculty with dairy and livestock responsibilities has improved its image as the 'County Agricultural Professional' during the past ten years. This improvement in technical expertise has been encouraged by the CES Administration through various professional in-service training opportunities, comprehensive subject matter seminars, and inter- and intrastate training tours. In addition, county CES faculty has increasingly used appropriate University of Wisconsin WISPLAN Computing Service Computer Decision Aid (CDA) programs to augment subject matter teaching.

CDA's have served as effective teaching tools for both county and state-wide faculty charged with implementing the dairy educational program (Howard & Wollenzein, 1985; Howard, Wollenzein, Hendrickson, Drost & Nehring, 1974). Several CDA's used extensively by county faculty, for example Badger Balancer (BB), Least Cost Dairy (LCD), Total Mixed Ration (TMR), are all dairy ration formulation programs. Other CDA's used are Silo Sizing, Forage Silo Inventory, Dairy AI Sire Selection, Whole Farm Budgets, Partial Budgets and Loan Amortization. The BB, LCD, and TMR are the most frequently used CDA's. In 1984, the dairy ration programs were accessed more than 7 800 times to formulate more than 15 000 rations for more than 5 000 farms representing over 250 000 cows (Rohweder, Howard, Schulte & Ballweg, 1985b). Past and current user surveys have documented a US \$72 – 100 per cow increased annual profit (Howard, *et al.*, 1979; Rohweder, *et al.*, 1985b). This translates to a multi-million dollar impact on Wisconsin dairy farms. The economic impact of these dairy ration formulation programs in rural Wisconsin has been one of Wisconsin Cooperative Extension Service's most dramatic success stories.

The dairy ration CDA's have greatly increased effectiveness in teaching dairy nutrition and feeding management to county CES faculty and their clientele. Using BB, LCD and TMR programs has promoted growth in their, as well as the authors', understanding of nutrition and practical feeding management (Howard & Wollenzein, 1985). In 1972, county faculty noted increased use of laboratory analyses of feeds. They were unsure of how to interpret these analyses in teaching farmers to improve feeding programs for their dairy herds. The Badger Balancer was developed to assist them in using feed analyses in their educational programming. Recently, reports from county faculty helped speed the decision to include additional analyses into the BB program to improve

its ration formulation accuracy. The TMR program was developed to help county faculty provide educational assistance to dairy farmers feeding total mixed rations. TMR was also developed to provide a tool to help county faculty quickly evaluate a feeding program.

The BB program has evolved through 13 revisions since 1973, each revision added features and became more comprehensive than the previous version. Recent revisions were made to incorporate use of forage acid-detergent fibre (ADF) and neutral-detergent fibre (NDF) analyses to increase ration formulation accuracy. Our philosophy has been to provide ration formulation programs that are easily understood and used by county Extension faculty whilst formulating rations acceptable to dairy farmers. Some of the revisions were made as a result of feedback from county faculty and farmers using the rations. One must not underestimate the importance of verifying the accuracy of ration formulation by consulting the dairy manager to determine the cow's performance when fed the ration.

Ration formulation computer programs provide the subject matter specialist a ready vehicle to help deliver current and changing nutrition technology to clientele. For example, BB and TMR were revised in 1984 to include use of neutral-detergent fibre (NDF) to describe diet forage limits (Howard & Earleywine, 1986; Rohweder, *et al.*, 1985b).

Laboratory analyses have been used since the first version of the BB was implemented in 1973. During the past 3 years Wisconsin farmers' use of forage analyses has more than tripled. In Wisconsin, we now have seven private commercial and two University of Wisconsin laboratories providing the Near Infrared Spectroscopy (NIRS) forage analyses. The NIRS forage testing program has made possible the ration formulation using NDF as well as selling tested hay at public auctions and alfalfa yield and quality contests. The alfalfa yield contest winners were determined on the basis of milk production potential per acre. Rations for cows producing 45 kg of 4%-fat milk were formulated. Production of milk above maintenance from forage were then calculated. The top producer in the 1985 contest achieved nearly 18 tonnes alfalfa dry matter per hectare. The winning producer more than doubled the average Wisconsin alfalfa yield. The milk production per hectare exceeded 15 000 l with a market value of over US \$3 800. Use of milk per unit of land has gained a far greater respect for alfalfa. Alfalfa is our most valuable feed crop. More than 100 tested hay auctions were scheduled from September 1985 to April 1986. Farmers have realized about US \$20–30 per 454 kg more than by selling the hay at private treaty (Rohweder, *et al.*, 1985b). The highest impact innovations contributing to improved professionalism during the past several years have been the implementing of NIRS forage analyses, using ADF to estimate energy value of forage and NDF to predict forage intake as well as minimum and maximum forage. In this paper we will concentrate on the use of ADF and NDF in dairy rations.

Using neutral-detergent fibre in ration formulation programs

Forage NDF has been suggested as the fibre measure of choice by several researchers (Jorgensen, Santini & Crowley, 1981; Kawas, Jorgensen, Hardie & Danelon, 1983; Mertens, 1986; Mertens, 1982; van Soest & Mertens, 1984). NDF has a higher correlation with forage intake than acid-detergent fibre or crude fibre (Jorgensen, *et al.*, 1981; Kawas, *et al.*, 1983; Mertens, 1982, 1986; Rohweder, *et al.*, 1985b; van Soest & Mertens, 1984). Currently, Wisconsin Extension and Cornell

Table 1 Forage neutral-detergent fibre (NDF) and TMR minimum forage intake for 600-kg cows

Forage NDF (% DM)	Forage ^a (% DM)	kg 4% FCM/day		
		15 (kg Forage dry matter/day)	25	35
35	60,0	9,9	11,3	12,7
40	52,5	8,7	9,9	11,1
45	46,7	7,7	8,8	9,9
50	42,0	7,0	7,9	8,9
55	38,2	6,3	7,2	8,1
60	35,0	5,8	6,6	7,4

^aMinimum forage limit in WISPLAN TMR (Howard, 1985)

University (New York) Extension scientists are formulating lactating dairy cow diets using a minimum of 21% NDF from forage in the diet dry matter (L. Chase, personal communication; Rohweder, *et al.*, 1985b). Use of NDF to specify minimum forage needs is illustrated in Table 1. The forage particle size must be adequate to maintain normal rumen function and milk fat composition. Cows must spend 550–600 min daily eating and ruminating to maintain normal milk fat test (Jorgensen, *et al.*, 1981). Milk fat test declines when diet forage particle size is too small. Wisconsin has not implemented a 'particle size' test for routine forage analyses. Several scientists, including Mertens at the US Dairy Forage Research Laboratory, are attempting to develop analytical procedures to evaluate particle length in forages and other feeds. Our recommendation for the theoretical length of chop (TLC) has been 0,635–0,95 cm depending on the individual forage chopped. Further, we recommend that Wisconsin dairy farmers maintain the fineness of chop so that 10–15% of the alfalfa silage stem pieces are longer than 2,54–3,79 cm.

NDF is also used to calculate the maximum forage in the diet dry matter. Maximum percentage NDF from forage in the TMR program is calculated by the following equation:

$$\begin{aligned} \text{Maximum diet percentage NDF from forage} \\ &= (0,42 - 0,088 \times \text{daily kg fat}) \times 100 \\ 33,2\% \text{ NDF from forage} \\ &= (0,42 - 0,088 \times 1,0 \text{ kg daily fat}) \times 100 \end{aligned}$$

Examples using NDF to describe maximum forage for lactating cows are shown in Table 2. The energy demands of the cow producing 40–50 kg/day result in diets close to the minimum forage. Use of NDF from non-forage feeds to describe total diet fibre is very difficult and currently not practical due to small particle size and differences in the NDF from non-forage feeds such as beet pulp, brewers grains, corn gluten feed, citrus pulp, and wheat bran.

Table 2 Forage neutral-detergent fibre and maximum forage intake for 600-kg cows

Forage NDF (% DM)	kg 4% FCM/day			
	15	25	35	45
	(maximum forage, % diet dry matter ^a)			
35	100	95	85	75
40	92	83	74	65
45	82	74	66	58
50	73	66	59	52
55	67	60	54	47
60	61	55	49	43

^aMaximum forage limit in WISPLAN TMR (Howard, 1985)

The BB program formulates diets using forage NDF to set forage intake for cows at 27,3 kg milk/day at 3,8% milk fat. The program estimates forage intake as follows:

$$\text{Forage DM, kg} = W^{0,75} * 0,043 / (\text{Forage } \% \text{ NDF} / 100)$$

$$12,36 \text{ kg Forage DM} = 635^{0,75} * 0,043 / (44\% \text{ NDF} / 100)$$

The BB program increases forage intake by 0,45 kg DM at 22,7 kg 3,8%-fat milk and another 0,45 kg at 18,2 kg 3,8%-fat milk. BB decreases forage intake by 0,45 kg at 31,8 kg 3,8%-fat milk and an additional 0,45 kg at 36,4 kg 3,8%-fat milk. BB increases grain-concentrate to meet energy needs up to 36,4 kg milk/day and then adds only the needed amount of protein supplement for the next 4,5 kg milk/day. Table 3 illustrates the total ration proportion NDF from forage as formulated by the BB program. The BB program assumes *ad libitum* forage feeding.

Table 3 Proportion of forage and forage NDF in Badger Balancer

Forage NDF (% DM)	kg 4% FCM/day				
	18,2	22,7	27,3	31,3	36,4
	(proportion of diet DM from forage ^a)				
35	90,7	83,1	76,3	70,2	64,7
40	80,0	73,0	66,7	61,1	56,1
45	71,7	65,2	59,3	54,1	49,4
50	65,0	58,9	53,4	48,5	44,0
55	59,6	53,8	48,5	43,9	39,6
60	55,1	49,5	44,5	40,0	36,0

^aProportion forage used in WISPLAN Badger Balancer (Howard, 1985)

Using acid-detergent fibre to estimate forage energy value

During the past several years a committee of national leaders from the agronomic, dairy and livestock disciplines have worked through the National Hay Grading and Marketing Task Force to develop standards or grades for hay offered for sale. Rohweder, Ballweg, Howard, Dantoin & Schulte summarized research data when forage digestible dry matter had been measured for milking cows (Rohweder, *et al.*, 1985a). These workers generated a single equation to estimate forage digestible dry matter (DDM) for temperate season alfalfa and alfalfa-grass mixtures. The equation has also been used to estimate the energy value of corn silage. The equation predicting DDM is used as an estimate of TDN or net energy-lactation. The predicted values are in close agreement with Mertens's recent equations developed to predict TDN at three times maintenance intake or net energy-lactation (Mertens, 1985).

The equation now used in Wisconsin to estimate energy value of these forages is as follows

$$\text{Digestible Dry Matter (DDM) } \% = 88,9 * 0,779 * \% \text{ADF} \quad (R^2 = 0,77) \quad (\text{Rohweder, et al., 1985a})$$

$$64,0\% \text{ Alfalfa DDM} = 88,9 - 0,779 * 32\% \text{ADF.}$$

Combining the NDF for intake specification and ADF to specify the energy value for forages has resulted in major increased use of forage analyses in ration formulation. Our ability to predict forage energy intake has been the missing link in dairy ration formulation. Wisconsin dairy farmers have reported they can now predict forage intake before feeding from the ADF and NDF analyses (Rohweder, *et al.*, 1985b). The BB, TMR and LCD programs all have been developed

with the philosophy that the dairy manager must balance the diet of the high-producing cow to meet her daily needs for protein, minerals, fibre and vitamins (NRC, 1978). We do not intend or pretend to be able to balance energy needs from the diet intake of the high-producing cow during early lactation. Our intent is to balance the cow's energy needs for lactation. We attempt to achieve maximum energy intake without adversely affecting rumen function and milk fat test. Attempting to meet the energy demand in early lactation from diet energy results in excess grain feeding. The cow in early lactation supplements diet energy with energy from body fat reserves. We have included mass loss in our LCD program and the ability to formulate diets in BB and TMR do not meet energy requirements during early lactation. Our experience indicates a maximum of 45–50 l of 4%-fat milk is the maximum production at energy balance for a cow weighing 650 kg at 60–90 days into lactation.

Good communication between the computer program author, programmer and the people in the field expected to use the program is required to develop accurate, efficient and appropriate Extension programs. The BB and other ration programs were developed using the input and counsel from county Extension faculty and dairy managers. Our dairy ration formulation programs were developed to help county faculty be more effective and efficient in helping Wisconsin farm families maintain profitable feeding programs. The dairy managers will decide whether the program developers have demonstrated that they know how to feed high-producing cows before using the resulting diets on their farms. They will evaluate the rations for practicality and whether the rations are in reasonable agreement with feeding programs they know have been successful with high-producing cows. We in Wisconsin believe, with over 5 000 farms using diets formulated with the three programs, that farmers have agreed that we know how to feed good cows. Currently, a Manitowoc county Wisconsin dairy farmer feeding TMR formulated rations for a three-group total mixed ration feeding program is producing 34 l of 3,8%-fat milk per milking cow in his 80-cow herd. His best cow produced 64 l of 3,7%-fat milk on the official test day in February. We believe we must be able to formulate rations acceptable to dairy managers with the skills and quality of cows to reach these and higher production levels.

Benefits from use of dairy ration programs

The Wisconsin dairy CDA's help solve specific problems faced by county Extension faculty every day. Furthermore, CDA's have helped build continuity and a more consistent state-wide Extension dairy nutrition program. By including use of the BB, LCD and TMR programs in the state-wide dairy program effort, we have been better able to maintain continuity in county dairy nutrition programming. Counties have different major programs each year, but by using BB, LCD and TMR they are able to maintain a strong, visible and continuing dairy nutrition program.

Perhaps the most important benefit to a specialist, with state-wide responsibilities, has been the development of a co-worker or partner relationship with the county faculty that has helped deliver higher quality dairy educational programming. As a state-wide nutrition specialist, my effectiveness can be measured by how well the county faculty build strong educational programs using the diet formulation programs we have jointly developed. The dairy ration formulation CDA's have increased my effectiveness in delivering dairy nutrition education to Wisconsin farmers through the county Extension faculty.

CDA's provide a vehicle to rapidly incorporate new technology into the county dairy educational program. For example, during 1986 the National Research Council will release their revised Nutritional Requirements for Dairy Cattle. We will be able to incorporate most of their changes into our CDA's within a few days; thereby keeping the county faculty as close as possible to the cutting edge of current technology. Extension must continually be looking for opportunities to demonstrate that we are attempting to stay at the cutting edge of new technology as well as developing new technology. Extension's linkage at the University of Wisconsin-Madison where we have integrated Teaching, Research and Extension departments in the College of Agricultural and Life Sciences has kept Extension faculty close to the research base essential to sound, progressive educational programs. University of Wisconsin dairy nutrition researchers Neal Jorgensen, Larry Satter and others have helped define and refine the nutrition subject matter embodied in the Wisconsin Extension dairy CDA's. This co-worker relationship with these research workers is as vital as the relationship with county faculty and farmers when building sound ration formulation programs.

The dairy ration formulation programs have enabled more accurate and defensible documentation of impact of our educational efforts. Surveys in 1978 and 1984 documented the multimillion dollar positive impact from use of the BADGER BALANCER, LCD and TMR (Howard & Wollenzein, 1985; Howard, *et al.*, 1979; Schmidt & Howard, 1980; Rohweder, *et al.*, 1985b). These documented benefits have proven very helpful in gaining increased budget support from state government.

Benefits to County Extension faculty

Programs such as BB, TMR and LCD have helped county faculty develop greater depth and expertise in dairy nutrition, feeding, and management. This increased expertise has been instrumental in bringing new clientele to use Extension's educational services. Another benefit has been the impression gained by farmers that the county agent is a quality professional using the professional 'tools of the trade' resulting from the assistance provided by use of the forage and feed analyses and BB, LCD or TMR. These programs have frequently been the 'foot in the door for Extension' to many farm families and agri-business firms. The experience of agents frequently has been that after helping with ration formulation, the farmer has confidence in the county agent to ask for help in other areas of need. The agent's reputation spreads by 'word of mouth'. Success in using the ration CDA's rapidly increases the demand for ration and other assistance very rapidly. Using dairy ration CDA's require one to be ready, willing and able to defend the nutrition technology used in formulating the rations. Extension's use of sound, practical, and economical dairy ration formulation, by hand calculation or computer formulation has at times not been enthusiastically received by some in the feed industry. We view our role in Wisconsin as the providers of unbiased quality information, permitting farmers to evaluate the alternatives and make decisions for the welfare of their farm and family.

Use of CDA's greatly increase labour efficiency by reducing the time required to do the arithmetic needed to formulate dairy rations. Agents can focus on answering the farmer's questions and not on trying to avoid calculation errors. Agents have a feeling of security in using the Wisconsin dairy CDA's because they know they have the full support and back-up from the University of Wisconsin Dairy Science Department as well as the programs author.

Using CDA's builds stronger co-worker relationships with the state-wide subject matter sponsor of the CDA. The interaction with state-wide faculty helps the specialist obtain needed information to build CDA's that help county faculty to teach more effectively.

CDA's have helped county faculty gain access to many new Extension clientele. For example, many county agents now have routine contact and referrals from veterinarians, feed dealers, agricultural lenders and others stemming from successful use of CDA's to help farmers. Increasingly, county agents are enlisting other agri-business firms to help deliver educational information by recommending they become external users of University of Wisconsin-Extension's WISPLAN Computing Service computer information system. The Wisplan Computing Service develops and maintains CDA's for the Extension faculty. This multiplies the number of farmers an agent can serve and protects the agent from criticism on his serving a limited number of farmers and on becoming a 'consultant' instead of an educator.

CDA's help inexperienced agents to rapidly gain the skills and confidence to become effective Extension educators. Use of the BB program has been very effective in promoting early professional success and serves to highlight areas of need for further training to the agent. BB is very easy for use by faculty with limited nutrition training.

Use of CDA's as an integral part of the Extension programming permits experienced agents to serve as a 'Big Brother/Sister' to new agents in a district or group of counties. This mutual support system builds greater individual expertise and therefore greater professional respect from clientele.

Participation in development and implementation of CDA's has kept the enthusiasm high among agents for delivering educational programs. Including county faculty at every level of CDA development, testing and revision has helped avoid 'top down programming'. The goal must be to build CDA's that help the county faculty do their job better and more efficiently.

The tremendous economic impact resulting from use of dairy CDA's on Wisconsin farms has been and continues to remind county faculty that the work they do often has had a US \$10 000–30 000 annual benefit to a single dairy farm family. The impact from use of CDA's helps build pride in our work and restores egos during the difficult times when we begin to doubt the value of our work.

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