Comparison of Software Applications for Formulating Dairy Rations

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Introduction

A variety of software programs are available in the marketplace from both university and private industry. The ***Nutrient Requirements of Dairy Cattle*** published by the National Research Council (**NRC**) provides the foundation for most programs. While this brings some commonality to the software available, generation of new knowledge in dairy nutrition occurs more rapidly than a new NRC can be published. Therefore, developers of software often modify the requirements based on more recently published research, geographical peculiarities or factors not explicitly considered by the most recent NRC.

Ration programs will, to some degree, contain similar components or inputs in order to develop a feeding program. These components may include, but are not limited to inputs concerning: description of the animal for which the diet is intended, identification and selection of ingredients, nutrient and ration constraint input, selection of a ration formulation objective, results and analysis of the formulation and report output. However, programs can differ greatly in the amount of input needed, the number of nutrients and feeds used in balancing, the type of objective functions available for ration formulation and completeness and versatility of report writing. These considerations, coupled with the flexibility to tailor the program to the users needs, play a significant role in the decision to purchase and use a particular piece of software.

Due to the number and variety of software packages available, selection of an appropriate ration formulation program can be time consuming. The purpose of this paper is to create a guide to aid in software selection by evaluating a variety of commercially available software, from both university and private industry sources. Table 1 contains a list of the software reviewed and the type of format in which they are available. Areas evaluated include: feed composition databases, dry matter intake and nutrient requirement estimates, animal description input options, general data input and management, formulation objective functions, and report writing. While this list is not exhaustive, it should provide the reader with a good *jump-start* into identifying a suitable ration formulation program.

Feed Composition Databases

Knowledge of the composition of feedstuffs is one of the most important aspects in properly formulating diets. Although it is commonly recommended that feeds, especially forages, be analyzed prior to balancing diets, some nutrients or components in forages are frequently not determined, and several concentrate ingredients may not be analyzed even though they can be highly variable in composition. The default values for nutrient concentrations are from tabular values when analytical values are not obtained. The NRC (1989) used various publications to compile feed composition tables, and this publication is commonly used as a source for tabular values. Bucholtz (1997) observed that coefficients of variation for crude protein (**CP)**, neutral detergent fiber (**NDF**) and crude fat within various commodities ranged from 4 to 35, 10 to 81 and 12 to 60%, respectively. The mineral composition of commodities has been found to be highly variable, often more variable than the organic components.

Tables 2 and 3 present the organic constituents for corn silage, ground corn, soybean meal, whole cottonseed, wheat middlings, blood meal and tallow from both the 1989 and 2001 NRC and the various ration formulation programs. For feedstuffs from the new 2001 NRC, net energy of lactation (**NE_L**)values are presented for a cow fed at 3X maintenance. The mean NE_L value for all feeds listed in the 2001 NRC are approximately 2% lower than the mean NE_L value for the same feeds in the 1989 NRC. Although, on average, the values are similar, some marked differences exist. In general, forages, especially lower quality forages, have lower NE_L values, high protein feeds have higher NE_L values and starchy concentrates have values similar to those in the 1989 NRC. The NE_L for cottonseed is about 16% lower than in the previous edition. The 1989 NRC appeared to be the primary standard used by most of the programs for development of their ingredient databases. Values for CP, NDF, acid detergent fiber (**ADF**) and fat were similar among the programs. However, the energy values were somewhat variable among feeds from the different databases, which should be expected given that energy is not determined analytically and several methods are used to estimate energy values.

Table 1: Ration formulation software evaluated.

Company	Program Name	System Requirements[a,b]	Program Type
ACS Computer Services 10800 Lincoln Heights Hagerstown, MD 21740	Dairy Ration System for Windows (DRSW)	Windows 3.1/95/98	Evaluation Least-cost
Agri-Data Systems, Inc. 21620 N. 19th Avenue, Suite A-10 Phoenix, AZ 85027	Dairy Ration System II (DRSII)	DOS 2.1 or higher	Evaluation Least-cost
Central Valley Nutritional Associates 3320 E. Mineral King Avenue Visalia, CA 93292	Formulate2 (Form2)	DOS 6.0 or higher	Evaluation Multiple objectives[c]
Cornell Univ. Animal Science Department 130 Morrison Hall Ithaca, NY 14853	CPM Dairy (CPMD)	Windows 95/98/NT	Evaluation Least-cost
Dalex Computer Systems, Inc. 4165 Shoreline Drive, Suite 40 Spring Park, MN 55384	The Consulting Nutritionist (TCN)	Windows 95/98/00/NT	Evaluation Least-cost
Easy Systems, Inc. 2550 Northwinds Parkway, Suite 225 Alpharetta, GA 30004	Brill Formulation Multi-Species Ration Balancer (Brill)	Windows 95/98/00/NT	Evaluation Least-cost
MSU Bulletin Office 10B Agriculture Hall Michigan State University East Lansing, MI 48824-1039	Spartan Dairy Ration Evaluator/Balancer (Spartan)	DOS 2.1 or higher	Evaluation Least-cost
Profit Source 10458 County Road F Athens, WI 54411	RationPro (RtnPro)	Windows 3.1/95/98/00	Evaluation Least-cost
The Ohio State University 221 Animal Science 2029 Fyffe Road Columbus, OH 43210	Ohio Dairy Ration Program (ODRP)	DOS 2.1 or higher	Evaluation Least-cost
TriLogic Systems P.O. Box 2979 Iowa City, IA 52244	DairyMax (DMax)	DOS 2.1 or higher	Evaluation Least-cost Maximum profit
Univ. of California Extension Software Support & Distribution Department of Animal Science Davis, CA 95616-8521	PCDairy-2 (PCD2)	DOS 3.3 or higher	Evaluation Least-cost Maximum profit

[a]Minimum system requirements.
[b]All DOS version software is Windows compliant and may be run on Windows 3.1/95/98 systems.
[c]Program provides for multiple formulation objects. See text.

Table 2: Composition values of corn silage, ground corn and soybean meal from the different databases[a].

Item	89NRC	01NRC	CPMD	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN
Corn silage, well eared													
DM, %	33.0	35.0	35.0	35.0	30.0	35.0	33.0	33.0	33.0	33.0	33.0	33.0	35.0
CP, % of DM	8.1	8.8	8.0	8.8	8.1	8.1	8.1	8.0	8.1	8.1	8.1	8.1	8.0
RDP, % of CP	69	65[b]	72	69	69	70	69	60	69	78	—	65	80
Soluble CP, % of CP	—	—	45	52	—	30	45	45	—	50	—	50	55
NDF, % of DM	51.0	45.0	41.0	45.0	51.0	42.0	51.0	51.0	51.0	48.0	51.0	51.0	41.0
ADF, % of DM	28.0	28.1	—	28.1	28.0	22.0	28.0	28.0	28.0	28.0	28.0	28.0	27.0
Fat, % of DM	3.1	3.2	3.5	3.1	3.1	3.1	3.1	3.0	3.0	3.1	3.1	—	3.5
NE_L, Mcal/lb	.73	.66[c]	.77	.74	.67	.73	.73	.73	.72	.73	.73	.73	.78
TDN, % of DM	70	69	—	—	65	72	70	70	70	70	71	70	72
Corn, ground													
DM, %	88.0	88.1	88.0	89.0	88.0	88.0	88.0	88.0	88.0	89.0	88.0	88.0	88.0
CP, % of DM	10.0	9.1	9.8	9.1	10.0	10.0	10.0	10.0	10.0	10.9	10.0	10.0	9.8
RDP, % of CP	48	53[b]	51	48	40	50	20	50	48	48	57	50	45
Soluble CP, % of CP	—	—	11	5	—	10	8	12	—	11	—	12	11
NDF, % of DM	9.0	9.5	9.0	9.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
ADF, % of DM	3.0	3.4	—	3.4	3.0	3.0	3.0	3.0	3.0	3.0	3.0	4.0	3.0
Fat, % of DM	4.3	4.2	4.3	4.2	4.3	4.3	4.3	4.0	4.3	4.3	4.3	—	4.3
NE_L, Mcal/lb	.89	.91[c]	.97	.95	.89	.90	.89	.89	.89	.91	.89	.89	.97
TDN, % of DM	85	89	—	—	85	85	85	85	85	87	85	85	85
Soybean meal, high protein													
DM, %	90.0	89.5	90	89.5	90.0	89.0	90.0	91.0	90.0	90.0	90.0	89.0	90.0
CP, % of DM	55.1	53.8	55.0	53.8	55.1	55.0	55.1	55.0	55.1	55.1	55.1	53.9	52.8
RDP, % of CP	65	57[b]	67	64	65	70	65	70	65	68	80	70	65
Soluble CP, % of CP	—	—	20	20	—	20	20	20	—	20	—	20	20
NDF, % of DM	8.0	9.8	8.0	9.8	8.0	10.0	8.0	8.0	8.0	10.0	7.8	9.0	7.8
ADF, % of DM	6.0	6.2	—	6.2	6.0	6.0	6.0	6.0	6.0	3.7	10.0	5.0	6.0
Fat, % of DM	1.0	1.1	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.5	—	1.1
NE_L, Mcal/lb	.91	1.0[c]	.86	.84	.91	.91	.91	.91	.91	.91	.91	.91	.96
TDN, % of DM	87	81	—	—	87	87	87	87	87	87	87	86	81

[a]89NRC = National Research Council 6th Ed., 01NRC = National Research Council 7th Ed., CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.

[b] Example RDP (% of CP): DMI = 4.0% of BW, forage = 50% of DMI.

[c] Estimated NE_L (Mcal/lb): Cows fed at 3X maintenance, diet TDN = 74%.

Table 3: Composition values of whole linted cottonseed, wheat middlings, blood meal and tallow from the different databases[a].

Item	89NRC	01NRC	CPMD	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN
Cottonseed, whole linted													
DM, %	92.0	91.0	92.0	90.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
CP, % of DM	23.0	23.5	24.4	23.5	23.0	23.0	23.0	23.0	23.0	25.0	23.0	23.0	24.4
RDP, % of CP	—	77[a]	71	68	—	60	23	65	65	80	70	70	70
Soluble CP, % of CP	—	—	40	33	—	30	40	40	—	40	—	33	40
NDF, % of DM	44.0	50.3	51.6	52.3	44.0	44.0	44.0	44.0	44.0	37.0	44.0	44.0	51.6
ADF, % of DM	34.0	40.1	—	42.1	34.0	34.0	34.0	34.0	34.0	26.0	34.0	34.0	35.0
Fat, % of DM	20.0	19.3	17.5	19.2	20.0	20	20.0	20.0	20.0	23.8	20.0	—	17.5
NE_L, Mcal/lb	1.01	.88[b]	.91	.88	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	.99
TDN, % of DM	96	77	—	—	96	96	96	96	96	96	96	96	90
Wheat middling													
DM, %	89.0	89.5	89.0	89.5	90.0	89.0	89.0	89.0	89.0	89.0	89.0	89.0	89.0
CP, % of DM	18.4	18.5	18.4	18.5	17.2	18.4	18.4	18.0	18.4	18.4	18.4	18.4	18.4
RDP, % of CP	79	76[a]	75	79	—	70	79	50	79	86	77	80	74
Soluble CP, % of CP	—	—	40	40	—	40	18	40	—	40	—	40	40
NDF, % of DM	37.0	36.7	35.0	36.7	44.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	35.0
ADF, % of DM	10.0	12.1	—	12.1	13.0	10.0	10.0	10.0	10.0	8.2	10.0	10.0	11.1
Fat, % of DM	4.9	4.5	3.2	4.5	4.6	4.9	4.9	5.0	4.9	4.9	4.9	—	3.2
NE_L, Mcal/lb	.71	.76[b]	.82	.78	.83	.71	.72	.71	.71	.71	.71	.71	.92
TDN, % of DM	69	73	—	—	79	69	69	69	69	69	69	69	85
Blood meal													
DM, %	92.0	90.2	90.0	90.0	—	92.0	93.0	92.0	92.0	—	92.0	92.0	90.0
CP, % of DM	87.2	95.5	93.0	95.5	—	87.0	87.2	87.0	87.2	—	87.2	87.2	93.8
RDP, % of CP	18	23[a]	22	18	—	20	18	20	15	—	25	35	25
Soluble CP, % of CP	—	—	4	2	—	5	5	10	—	—	—	10	5
Fat, % of DM	1.4	1.2	1.7	1.2	—	1.4	1.4	1.0	1.4	—	1.4	—	1.7
NE_L, Mcal/lb	.68	1.06[b]	.95	.65	—	.68	.68	.68	.68	—	.68	.68	.73
TDN, % of DM	66	76	—	—	—	66	66	66	66	—	—	66	66
Tallow													
DM, %	99.0	99.8	99.0	98.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Fat, % of DM	99.5	99.8	100	100	99.5	99.5	99.5	100	99.5	99.5	99.5	—	99.0
NE_L, Mcal/lb	2.65	2.05[b]	2.84	2.95	2.65	2.65	2.65	2.65	1.91	2.44	2.65	2.65	2.65
TDN, % of DM	177	147	—	—	177	177	177	177	177	225	177	177	177

[a]89NRC = National Research Council 6th Ed., 01NRC = National Research Council 7th Ed., CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.

[a] Example RDP (% of CP): DMI = 4.0% of BW, forage = 50% of DMI.

[b] Estimated NE_L (Mcal/lb): cows fed at 3X maintenance, diet TDN = 74%.

Significant variation existed among the programs for concentrations of rumen degradable protein (**RDP**). The 1989 NRC provided limited data regarding the degradability of protein fractions within feedstuffs. Therefore, most of the software programs have undoubtedly relied on other sources for this information.

Dry Matter Intake and Nutrient Requirements

Establishment of dry matter intake (**DMI**) and nutrient requirements is another important step towards developing a properly formulated ration. The animals used for the comparisons in this paper are described in Table 4. It was assumed all cows were housed in a thermoneutral environment, in at least their third lactation and had a constant body weight. These assumptions were made to minimize confounding of how the programs determine nutrient requirements. The suggested DMI and nutrient requirements from the different sources were taken directly from the computer programs, including the diskette provided with the 1989 NRC.

There was no distinction in estimated DMI or nutrient requirements for dry cows between the 1989 NRC and the programs PCD2 or DMax (Table 5). Dry matter intake predictions for dry cows greater than 21d and 21 to 0d prepartum ranged from 1.45 to 2.05 and 1.43 to 2.0% of body weight, respectively. Six programs (PCD2, DMax, DRSII, DRSW, RtnPro and TCN) did not reduce their DMI predictions for cows within 21d of calving, which is similar to the 1989 NRC. The 2001 NRC reduced DMI 8% from 1.97% of BW for far-off dry to 1.82% of BW for close-up dry cows. The most significant change in DMI prediction came from the ODRP, Spartan, Brill and CPMD with reductions of 12.3, 17.5, 18.0 and 20%, respectively.

Estimates of CP intake for far-off and close-up dry cows ranged from 2.31 to 3.67 and 2.31 to 3.29 lbs/d. Crude protein requirements were similar for the 1989 and 2001 NRC, 2.85 and 2.82 lbs/d, respectively. Five programs had similar values, which included ODRP, PCD2, Brill, DMax and DRSW. Spartan had the highest CP intake estimate at 3.67 lbs/d. Net energy of lactation requirement estimates for both far-off and close-up dry cows ranged from 13.0 to 15.6 Mcal/d. Net energy of lactation requirement estimations from the 1989 and 2001 NRC were 13.5 and 13.0 Mcal/d, respectively. Eight programs (ODRP, PCD2, Spartan, Brill, DMax, DRSW, Form2 and TCN) had values similar to the 1989 NRC, while CPMD was in close agreement with the 2001 NRC value. Calcium and phosphorus requirements for dry cows were similar among all of the programs evaluated.

Estimated DMI for lactating cows at 30, 60, 100 and 250 DIM averaged 3.18, 4.15, 3.78 and 3.02% of BW, respectively (Table 6 and 7). There was no difference in estimated DMI or nutrient requirements between the 1989 NRC and DMax across all stages of production. Form2 was similar to 1989 NRC at 30 and 60 DIM, but not at 100 and 250 DIM. DRSII was similar to 1989 NRC at 30, 60 and 100 DIM, but not at 250 DIM. Estimated DMI was highest for Brill at 30 and 60 DIM, 3.60 and 4.32% of BW, respectively and highest for 2001 NRC at 100 and 250 DIM, 4.10 and 3.31% of BW, respectively. A recent comparison among 1989 NRC, ODRP, CPMD and Spartan (Eastridge et al., 1998) for predicting DMI in early lactation (≤ 8 weeks), showed that overall the 1989 NRC provided the most accurate estimation of DMI. However, at ≤ 4 weeks of lactation Spartan provided the best estimate of DMI (bias = + 0.44 lbs/d) among the programs evaluated in that study. For the current paper, the estimated DMI for cows 30 DIM from Spartan was 3.11% of BW. Dry matter intake estimates lower than Spartan were witnessed with the 2001 NRC, CPMD, RtnPro and TCN programs at 2.97, 3.01, 2.73 and 2.92% of BW, respectively. According to the discussion, the 2001 NRC DMI equation predicts DMI very closely to actual DMI for the first 10 weeks of lactation and then slightly under predicts DMI thereafter. This is interesting since the 2001 NRC produced the highest estimates of DMI at 100 and 250 DIM in the current comparison, indicating that all of the programs may be significantly under predicting DMI of cows greater than 100 DIM.

Estimated CP intake requirements for lactating cows at 30, 60, 100 and 250 DIM averaged 7.89, 10.85, 9.37 and 6.55 lbs/d, respectively and consisted of considerably more variation than estimates of NE_L requirements. Variation among the programs was least for predictions of CP intake at 60 DIM and greatest at 250 DIM. Among the programs evaluated only DMax had protein values in agreement with the 1989 NRC for all stages of production tested. The ODRP had the highest CP intake requirement at 30, 60 and 100 DIM, (8.64, 11.4 and 10.1 lbs/d, respectively), while DRSII had the highest requirement at 250 DIM (7.43 lbs/d). The lowest CP intake requirement predictions for 30, 60, 100 and 250 DIM were 7.58 (TCN), 10.7 (Spartan), 9.18 (1989 NRC, DMax, DRSII and Form2) and 6.04 (TCN) lbs/d, respectively.

As indicated previously, NE_L requirement values contained significantly less variation than protein requirement values for the lactating cow examples. Net energy of lactation values averaged 35.7, 47.2, 41.5 and 29.9 Mcal/d at 30, 60, 100 and

Table 4: Animal description used in the comparison of nutrient requirements from the NRC with requirements from different computer programs[a].

	Prepartum		Postpartum			
	> 21 d	21 to 0 d	30 DIM	60 DIM	100 DIM	250 DIM
Body weight, lbs	1450	1450	1450	1450	1450	1450
Body condition score	3.50	3.50	3.00	2.50	2.75	3.25
Days pregnant	220	270	0	0	0	150
Milk						
Yield, lbs/d	---	---	80	120	100	60
Fat, %	---	---	3.60	3.40	3.50	3.60
Total protein, %	---	---	3.30	3.10	3.20	3.30

[a]All cows were assumed to be housed in a thermoneutral environment, to be at least in their third lactation and to be gaining no weight.

Table 5: Suggested DMI and nutrient requirements for dry cows from different computer programs[a].

Item	89NRC	01NRC	CPMD[b]	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN[c]
>21d prepartum													
DMI, lb/d	23.8	28.6	29.0	23.6	23.8	28.2	29.7	23.8	27.4	28.0	21.0	30.0[f]	23.2
CP Intake, % of DM	12.0	9.9	—	12.0	12.0	13.0	9.6	12.0	12.0	10.2	12.0	7.7	13.0
CP Intake, lb/d	2.85	2.82[d]	—	2.84	2.85	3.67	2.85	2.85	3.29	2.85	2.52	2.31	3.02
NDF, % of DM	35	33	30	30	35	35	—	35	35	28	35	35	—
ADF, % of DM	27	21	—	19	27	16	—	27	27	19	27	27	—
NE_L, Mcal/lb	.57	.45	.45	.57	.57	.48	.45	.57	.57	.48	.64	.46	.58
NE_L, Mcal/d	13.5	13.0	13.1	13.4	13.5	13.5	13.5	13.5	15.6	13.5	13.5	13.9	13.5
Ca, % of DM	.40	—	.24	.45	.40	.39	.32	.40	.40	.18	.46	.33	.41
Ca, lb/d	.10	.04[e]	.07	.11	.10	.11	.10	.10	.11	.05	.10	.10	.10
P, % of DM	.25	—	.17	.26	.25	.24	.20	.25	.24	.21	.28	.20	.25
P, lb/d	.06	.04[e]	.05	.06	.06	.07	.06	.06	.07	.06	.06	.06	.06
21 to 0d prepartum													
DMI, lb/d	23.8	26.4	23.2	20.8	23.8	23.2	24.4	23.8	27.4	28.0	20.7	30.0[f]	23.2
CP Intake, % of DM	12.0	11.6	—	13.7	12.0	14.0	11.7	12.0	12.0	10.2	12.0	7.7	13.0
CP Intake, lb/d	2.85	3.06[d]	—	2.84	2.85	3.24	2.85	2.85	3.29	2.85	2.48	2.31	3.02
NDF, % of DM	—	33	30	30	35	35	—	35	35	28	35	35	—
ADF, % of DM	—	21	—	19	27	16	—	27	27	19	27	27	—
NE_L, Mcal/lb	.57	.50	.60	.65	.57	.60	.55	.57	.57	.48	.64	.46	.58
NE_L, Mcal/d	13.5	13.3	14.0	13.5	13.5	14.1	13.5	13.5	15.6	13.5	13.2	13.9	13.5
Ca, % of DM	.40	—	.34	.51	.40	.39	.39	.40	.40	.18	.45	.33	.41
Ca, lb/d	.10	.04[e]	.08	.11	.10	.09	.10	.10	.11	.05	.09	.10	.10
P, % of DM	.25	—	.22	.29	.25	.24	.24	.25	.24	.21	.28	.20	.25
P, lb/d	.06	.04[e]	.05	.06	.06	.06	.06	.06	.07	.06	.06	.06	.06

[a]89NRC = National Research Council 6th Ed., 01NRC = National Research Council 7th Ed., CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.

[b]Modified NRC requirements. CPM model requirements: > 21d Prepartum, ME = 21.7 Mcal/d, MP = 1.5 lbs/d, Methionine = 11 g/d, Lysine = 35g/d; 21 to 0d Prepartum, ME = 22.4 Mcal/d, MP = 1.6 lbs/d, Methionine = 10 g/d, Lysine = 33g/d.

[c]NRC requirements. Cornell model requirements: > 21d Prepartum, DMI = 29.0 lbs/d, ME = 19.1 Mcal/d, MP = 1.1 lbs/d, Methionine = 10 g/d, Lysine = 31g/d; 21 to 0d Prepartum, DMI = 29.0 lbs/d, ME = 19.1 Mcal/d, MP = 1.1 lbs/d, Methionine = 10 g/d, Lysine = 31g/d.

[d]Equivalent to crude protein only if rumen degradable protein and rumen undegradable protein are perfectly balanced.

[e]Total absorbed required

[f] 1500 pound cow, default DMI = 2% of BW

Table 6: Suggested DMI and nutrient requirements for lactating cows at 30 and 60 DIM from different computer programs[a].

Item	89NRC	01NRC	CPMD[b]	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN[c]
30 DIM													
DMI, lb/d	48.0	43.1	43.7	47.7	47.9	45.1	50.8	48.0	48.0	48.2	48.0	39.6	42.3
CP Intake, % of DM	16.5	17.8	—	18.1	16.0	17.6	15.3	16.5	16.5	16.4	16.5	19.6	17.9
CP Intake, lb/d	7.92	7.69[d]	—	8.64	7.77	7.92	7.77	7.92	7.92	7.90	7.92	7.76	7.58
NDF, % of DM	28	25	30	26	28	29	—	28	—	28	28	25	—
ADF, % of DM	21	17	—	19	21	16	19	21	—	21	21	19	19
NE_L, Mcal/lb	.74	.84	.82	.74	.74	.79	.70	.74	.74	.74	.74	.90	.84
NE_L, Mcal/d	35.7	36.0	36.0	35.3	35.7	35.7	35.4	35.7	35.7	35.7	35.5	35.5	35.7
Ca, % of DM	.63	—	.72	.70	.60	.72	.59	.63	.63	.62	.63	.76	.71
Ca, lb/d	.30	.14[e]	.31	.33	.30	.32	.30	.30	.30	.30	.30	.30	.30
P, % of DM	.40	—	.46	.40	.38	.42	.37	.40	.40	.39	.40	.48	.45
P, lb/d	.19	.12[e]	.20	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19
60 DIM													
DMI, lb/d	60.6	61.2	58.2	61.5	60.7	58.7	62.7	60.6	60.6	58.6	60.6	59.5	58.8
CP Intake, % of DM	17.8	17.3	—	18.6	18.0	18.2	17.3	17.8	17.8	18.4	17.8	18.3	18.4
CP Intake, lb/d	10.8	10.6[d]	—	11.4	10.9	10.7	10.9	10.8	10.8	10.8	10.8	10.9	10.8
NDF, % of DM	25	25	30	26	25	27	—	25	—	28	25	25	—
ADF, % of DM	19	17	—	19	19	16	19	19	—	21	19	19	18
NE_L, Mcal/lb	.78	.77	.82	.75	.78	.81	.75	.78	.78	.81	.78	.79	.80
NE_L, Mcal/d	47.3	47.1	47.6	46.1	47.3	47.3	47.0	47.3	47.3	47.5	47.3	47.1	47.3
Ca, % of DM	.68	—	.76	.73	.66	.76	.66	.68	.68	.70	.68	.69	.70
Ca, lb/d	.41	.19[e]	.44	.45	.41	.44	.41	.41	.41	.41	.41	.41	.41
P, % of DM	.43	—	.48	.42	.41	.44	.41	.43	.43	.44	.42	.43	.40
P, lb/d	.26	.17[e]	.28	.26	.26	.26	.25	.26	.26	.26	.25	.25	.26

[a]89NRC = National Research Council 6th Ed., 01NRC = National Research Council 7th Ed., CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.

[b]Modified NRC requirements. CPM model requirements: 30 DIM, ME = 56.3 Mcal/d, MP = 5.2 lbs/d, Methionine = 43 g/d, Lysine = 135 g/d; 60 DIM, ME = 74.6 Mcal/d, MP = 7.1 lbs/d, Methionine = 59 g/d, Lysine = 186 g/d.

[c]NRC requirements. Cornell model requirements: 30 DIM, DMI = 44.9 lbs/d, ME = 56.3 Mcal/d, MP = 5.3 lbs/d, Methionine = 43 g/d, Lysine = 145 g/d; 60 DIM, DMI = 59.4 lbs/d, ME = 75.9 Mcal/d, MP = 7.4 lbs/d, Methionine = 61 g/d, Lysine = 204 g/d.

[d]Equivalent to crude protein only if rumen degradable protein and rumen undegradable protein are perfectly balanced.

[e]Total absorbed required

250 DIM, respectively. Four programs, PCD2, Spartan, DMax and TCN, had identical energy values when compared to the 1989 NRC across all stages of production examined. The ODRP provided the lowest NE_L estimates. Values from the ODRP at 30, 60, 100 and 250 DIM were 35.3, 46.1, 40.5 and 29.0 Mcal/d, respectively. Net energy of lactation values from the 2001 NRC were 36.0 (30 DIM), 47.1 (60 DIM), 41.7 (100 DIM) and 29.6 (250 DIM) Mcal/d. The 36 Mcal/d estimate from the 2001 NRC at 30 DIM was the highest among the programs for that stage of production and was similar to the CPMD estimate.

Dry matter intake is the foundation from which rations are balanced; therefore, the accuracy of DMI prediction or estimation is extremely important. The most common factors used in the prediction of DMI are BW and FCM yield. Other factors incorporated into some equations include stage of lactation, parity, milk component yield, dietary components and environmental variables. Roseler et al. (1997) concluded that milk yield, BW, diet and management, climate and body condition score accounted for 45, 17, 22, 10 and 6%, respectively, of the variation in DMI. Milk yield and BW accounted for 62% of the variation, which explains why these variables are the most common in equations for predicting DMI. However, it should be remembered that no prediction equation is as accurate as actual measurement of DMI on the farm. Indeed, the 2001 NRC committee reminds its readers of this fact. All of the programs evaluated allow the user to enter their own DMI values directly, thus circumventing the use of the DMI prediction equation. Further, some programs allow the user to edit the prediction equations to more accurately reflect current research or field observation.

Overall, differences existed in recommendations for nutrient intakes among the programs. These differences in recommended nutrient intakes by the programs were accentuated by differences in DMI predictions when the nutrient recommendations were compared based on dietary concentration. Further, several dietary components existed in the computer software programs for monitoring purposes that do not exist in the 1989 NRC. These additions reflect changes in the field of dairy nutrition since the 1989 NRC recommendations and the freedom of software developers to include variables for which limited data may exist.

Animal Description

Table 8 contains a list of the animal description and production input information items for lactating and dry cows of the different computer programs. Animal descriptors required to generate lactating cow requirements from the 1989 NRC program diskette include: body weight, milk production, milk fat percent, days pregnant, lactation number, live weight change and a lead or discount factor for feed or NRC assumed energy concentration. The 2001 NRC allows input for up to seventeen items to describe the lactating cow and up to eleven input items for description of the dry cow. Only milk lactose percent, required by the 2001 NRC, was not part of the input needed by any of the other programs evaluated. All of the programs evaluated required an estimate of live body weight, milk production and milk fat percent for determination of lactating cow DMI and nutrient requirements. Other popular input items included, live weight change (11 programs), lactation number (9 programs), breed or breed type (5 programs) and milk protein percent (5 programs). The program most similar to the 2001 NRC for animal input information was CPMD. However, it should be noted that TCN is also similar to the 2001 NRC, when using the modified Cornell model portion of the program. Further, the TCN program allows for selection of one of three amino acid requirement calculation schemes and the use of one of two different DMI intake equations. Information required by both the 2001 NRC and CPMD but not the other programs included: age, age at first calving, body condition, calf birth weight, calving interval, and mature weight. Among the programs evaluated, four (01NRC, CPMD, PCD2 and Form2) allowed for an activity or grazing allowance, three (PCD2, DMax and Form2) allowed for input pertaining to the percent of 1st and 2nd lactation animal in the group and only Brill and DMax provided the ability to use a *lead factor* for lactating and lactating and dry cows, respectively. Six programs allowed for input of various environmental and housing conditions for both lactating and dry cows, however the effect that these input items had on DMI and (or) nutrient requirement calculations were not readily apparent for all of the programs requesting this input. Again, several items used to define the animal for which a particular ration is being formulated varied greatly among the programs evaluated and included items not considered by the 1989 NRC.

Data Management and Ration Formulation

Table 9 compares the major data management features of the different computer programs. The 2001 NRC program was not considered for this discussion since it is an evaluation program only and not intended for direct commercial use. In consideration of the major design and setup options among the programs evaluated, ODRP and DRSW did not allow for use of both the imperial and metric systems of measurement and ODRP did not allow interchangeable moisture

Table 7: Suggested DMI and nutrient requirements for lactating cows at 100 and 250 DIM from different computer programs[a].

Item	89NRC	01NRC	CPMD[b]	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN[c]
100 DIM													
DMI, lb/d	53.5	59.5	54.8	57.5	53.5	56.8	56.0	53.5	53.5	51.7	53.5	55.8	53.3
CP Intake, % of DM	17.2	16.2	—	17.6	17.0	16.5	16.7	17.2	17.2	17.8	17.2	16.8	17.5
CP Intake, lb/d	9.18	9.63[d]	—	10.1	9.35	9.35	9.35	9.18	9.18	9.20	9.18	9.40	9.30
NDF, % of DM	25	25	30	26	25	28	—	25	—	28	26	25	—
ADF, % of DM	19	17	—	19	19	16	19	19	—	21	19	19	18
NE_L, Mcal/lb	.78	.70	.76	.71	.78	.73	.74	.78	.78	.81	.78	.74	.78
NE_L, Mcal/d	41.6	41.7	41.9	40.5	41.6	41.6	41.4	41.6	41.6	41.9	41.6	41.4	41.6
Ca, % of DM	.67	—	.70	.68	.65	.68	.64	.67	.63	.69	.66	.64	.67
Ca, lb/d	.36	.17[e]	.38	.39	.36	.38	.36	.36	.36	.36	.35	.36	.36
P, % of DM	.42	—	.44	.39	.42	.40	.40	.42	.42	.43	.42	.40	.42
P, lb/d	.23	.15[e]	.24	.22	.23	.22	.22	.23	.23	.22	.22	.22	.22
250 DIM													
DMI, lb/d	41.5	48.0	44.0	45.3	41.5	45.9	44.4	41.5	46.0	44.4	41.5	44.2	41.4
CP Intake, % of DM	15.6	14.4	—	15.4	16.0	13.6	13.7	15.6	16.2	16.7	15.5	13.7	14.6
CP Intake, lb/d	6.46	6.91[d]	—	7.00	6.07	6.23	6.06	6.46	7.43	7.41	6.42	6.06	6.04
NDF, % of DM	28	25	30	26	28	30	—	28	—	28	28	25	—
ADF, % of DM	21	17	—	19	21	16	19	21	—	21	21	19	21
NE_L, Mcal/lb	.71	.62	.69	.64	.71	.64	.66	.71	.71	.73	.71	.66	.71
NE_L, Mcal/d	29.4	29.6	30.2	29.0	29.4	29.4	29.2	29.4	32.5	32.4	29.5	29.2	29.4
Ca, % of DM	.58	—	.58	.59	.60	.56	.54	.58	.63	.62	.58	.55	.58
Ca, lb/d	.24	.12[e]	.25	.27	.24	.26	.24	.24	.28	.28	.24	.24	.24
P, % of DM	.37	—	.37	.34	.38	.33	.34	.37	.42	.38	.37	.34	.37
P, lb/d	.15	.11[e]	.16	.15	.15	.15	.15	.15	.17	.17	.15	.15	.15

[a]89NRC = National Research Council 6th Ed., 01NRC = National Research Council 7th Ed., CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.

[b]Modified NRC requirements. CPM model requirements: 100 DIM, ME = 65.4 Mcal/d, MP = 6.5 lbs/d, Methionine = 54 g/d, Lysine = 170g/d; 250 DIM, ME = 47.0 Mcal/d, MP = 4.6 lbs/d, Methionine = 38 g/d, Lysine = 121 g/d.

[c]NRC requirements. Cornell model requirements: 100 DIM, DMI = 55.9 lbs/d, ME = 67.2 Mcal/d, MP = 6.5 lbs/d, Methionine = 53 g/d, Lysine = 179 g/d; 250 DIM, DMI = 45.1 lbs/d, ME = 56.4 Mcal/d, MP = 4.4 lbs/d, Methionine = 36 g/d, Lysine = 122 g/d.

[d]Equivalent to crude protein only if rumen degradable protein and rumen undegradable protein are perfectly balanced.

[e]Total absorbed required

Table 8: Animal description and production input information items for lactating (L) and dry (D) cows of the different computer programs[a].

Item	01NRC	CPMD	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro[e]	TCN
Activity or grazing allowance	L,D	L,D	–,–	L,D	–,–	–,–	–,–	–,–	–,–	L,D	–,–	–[f],–[f]
Age	L,D	L,D	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–[f],–[f]
Age at 1st calving	L,D	L,D	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–[f],–[f]
Body condition	L,D	L,D	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–[f],–
Body weight	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L[f],D[f]
Breed/breed type	L,D	–,–	–,–	–,–	L,D	L,D	–,–	L,D	–,–	L,D	–,–	–[f],–[f]
Calf birth weight	L,D	L,D	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–[f],–
Calving interval	L,D	L,D	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–[f],–[f]
Days in milk	L,–	L,–	L,–	L,–	L,D[d]	L,D[d]	–,–	L[e],–	L,–	L,D	L,–	L[f],–
Days pregnant	L,D	L,D	–,–	–,–	–,–	–,–	L,D	–,–	–,–	L,D	–,–	L[f],–
Lactation number	L,–	L,–	L,D	–,–	L,D	L,D	–,–	L,–	L,–	–,–	L,–	L[f],–
Lead factor	–,–	–,–	–,–	–,–	–,–	L,–	L,D	–,–	–,–	–,–	–,–	–,–
Live weight change	–,–	L,D	L,D	L,D	L[c],D[c]	L,–	L,D	L,D	L,–	L,D	L,–	L[f],D[f]
Mature weight	L,D	L,D	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–[f],–[f]
Milk lactose %	L,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–	–,–
Milk production	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L[f],–
Milk protein %	L,--	L,–	–,–	–,–	L,–	L,–	–,–	L,–	–,–	–,–	–,–	–[f],–
Milk fat %	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L,–	L[f],–
Percent 1st lactation	–,–	–,–	–,–	L,D	–,–	–,–	L,D	–,–	–,–	L,D	–,–	–,–
Percent 2nd lactation	–,–	–,–	–,–	L,D	–,–	–,–	L,D	–,–	–,–	L,D	–,–	–,–
Temperature	L[b],D[b]	L[b],D[b]	L,D	–,–	–,–	–,–	–,–	L[b],D[b]	L,D	–,–	–,–	–[b,f],–[b,f]

[a]01NRC = National Research Council 7th Ed., CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.
[b]Additional management and environment input considered which may or may not be associated with the animal information input screen.
[c]Optional screen available for input to calculate target daily weight change
[d]Days till fresh
[e]DMI for dry cows entered by user
[f]Information requested for modified Cornell model.

Table 9: Comparison of software features for data management from different computer programs[a].

Item	CPMD	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN
Design/setup											
Imperial and metric system	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
Interchangeable moisture basis	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Use % basis (P), amt/h/d (A), or both (B)	A	A	B	B	B	B	B	B	B	A	B
Rounding/decimal setting: static (S), variable (V)	S	S	V	V	V	V	S	V	V	S	V
Input											
Maximum nutrient count	60	29	36	39	200	70	60	60	48	38	200
Nutrients can be edited	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Nutrients can be created	N	N	Y	Y	Y	Y	Y	Y	N	N	Y
Nutrients can be calculated	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y
Allow nutrient formula editing	N	N	N	N	Y	Y	Y	N	N	N	Y
Maximum ingredient count per library	NL[b]	120	999	70	NL[b]	200	NL[b]	NL[b]	NL[b]	NL[b]	NL[b]
Use multiple ingredient libraries	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ingredients can be added/edited	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ingredient maximum per formulation	NL[b]	20	30	79	40	50	40	30	40	50	NL[b]
Mix ingredients	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Save a mix as an ingredient	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Use group constraints	N	N	Y	N	Y	Y	Y	N	Y	Y	Y
Use ratio constraints	N	N	Y	N	Y	Y	Y	Y	N	Y	Y
Nutrient constraints can be created	N	N	N	Y	Y	Y	Y	Y	N	N	Y
Allow nutrient constraint formula editing	Y	N	N	N	Y	Y	Y	Y	N	N	Y
Use dummy ingredients	Y	N	Y	Y	Y	Y	Y	N	N	N	N
Input cost basis: static (S), variable (V)	S	V	V	V	S	V	V	S	S	S	V
Additional features											
Multiple ration formulation	N	N	N	N	Y	N	Y	N	N	Y	Y
Multiple ration comparison	N	Y	N	N	Y	Y	Y	Y	N	Y	Y
Formulate least cost supplements	N	N	N	N	Y	N	N	Y	Y	N	Y
Balance minerals and vitamins	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provide amino acid analysis	Y	Y	N	N	Y	N	Y	Y	Y	N	Y
Import/export data	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y

[a]CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.
[b]NL = No limit

basis input selection. The programs CPMD, ODRP and RtnPro restrict the user to input of ingredient weights and ingredient usage constraints on an amount per head basis only.

All of the programs allow for editing of the nutrient content of ingredients contained within the programs libraries. The maximum number of nutrients allowed by the various programs ranged from 29 (ODRP) to 200 (Brill and TCN). The nutrient counts for CPDM (60), ODRP (29), Form2 (48) and RtnPro (38) are static and do not allow for the creation of new nutrients by the user. Brill, DMax, DRSII, and TCN offer the user the opportunity to edit or write new formulas for calculation of existing or user created nutrients.

With the use of multiple libraries all of the programs except ODRP have no practical limit on the number of ingredients that can be edited, created and stored by the user. Further, all of the programs allow mixing of multiple ingredients to form a new ingredient, and all programs except Spartan, allow the user to easily save the newly formed ingredient in an ingredient library. Only CPMD and TCN had no limit on the number of ingredients allowed in a single formulation run. The ingredient use restriction per formulation for the other programs were ODRP (20), PCD2 (30), Spartan (79), Brill (40), DMax (50), DRSII (40), DRSW (30), Form2 (40) and RtnPro (50).

All of the programs reviewed can function as a ration evaluator and allow the user to develop a ration formulation at least-cost. Both the DMax and PCD2 programs have a profit-maximizing objective function, while only Form2 offers up to four different optimization functions. These options include: a least cost function, minimization of concentrate costs, minimization of forage costs or minimization of *user-tagged* feeds. Six programs (Spartan, Brill, DMax, DRSII, DRSW and TCN) allow for the creation of new nutrient constraints and all but Spartan allow nutrient constraint formula editing. Along with nutrient constraints, the use of group and ratio constraints can be extremely helpful in controlling formulation results. All of the programs except CPMR, ODRP, and Spartan allow the use of such constraints. The CPMD and ODRP are the only programs that do not balance for minerals (except Ca and P) or vitamins and only PCD2, Spartan, DMax or RtnPro do not provide amino acid analysis. An additional option within the Brill, DRSII, RtnPro and TCN programs is the ability to formulate multiple rations at the same time. While Form2 will allow a similar process, using a common feed library, it requires many more steps than the previously mentioned programs.

Troubleshooting infeasible solutions can be a frustrating task. The use of *dummy* ingredients in a solution provides useful feedback to the user and can aid in determining additional ingredient or nutrient needs to bring about a reasonable solution. Programs incorporating this type of feedback include CPMD, PCD2, Spartan, Brill, DMax, and DRSII. Although TCN, RtnPro and DRSW do not allow for use of dummy ingredients, these programs will return solutions with flagged or highlighted nutrients indicating where problems exist in returning the infeasible solution. The Form2 program uses a text message box to indicate an infeasible ration was returned and limiting nutrients. Some of programs incorporate the use of a text message in combination with dummy ingredients or flagged nutrients to aid the use in identifying problems and possible solutions.

As mentioned previously, flexibility is an important consideration when deciding to purchase a particular software program. Overall, it appears that the commercial software products allow for more flexibility and user input than the university developed software. Among the commercial programs available, RtnPro appears to provide the fewest options for managing data and generating formulations while, Brill, TCN, DMax and DRSII provide the most flexibility.

Print Reports

Table 10 consists of the print report features and options from the different computer programs. The kinds of output from the programs are as varied as the programs themselves. At a minimum the user should be able to produce a concise comprehensive ration report containing a title describing the output, a description of the animal on which the evaluation was done, a summary of the type and amount of ingredients used, nutrient content of the ration and cost. This minimum requirement; however, is hardly enough to satisfy the needs of most users. Again, the university-developed programs offer fewer options in report writing than the commercial products. Both the ODRP and DMax programs provide little in the form of a comprehensive report previously described. Among the commercial programs, DRSII provides the most comprehensive list of reporting options. Batch or load mixing weights and ingredient blend weights could be provided by all of the commercial programs evaluated. However, there was considerable variation as to the organization and options available within these reporting sections.

Table 10: Comparison of print report features and options from different computer programs[a].

Item	CPMD	ODRP	PCD2	Spartan	Brill	DMax	DRSII	DRSW	Form2	RtnPro	TCN
Comprehensive report	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Animal description	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Animal requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ingredients and amounts	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ingredient nutrient profile	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Upper/Lower prices – ingredients used	N	Y	Y	Y	Y	Y	Y	N	N	N	N
Ingredients not used	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Opportunity prices – ingredients not used	N	Y	Y	Y	Y	Y	Y	Y	N	Y	N
Ration nutrient analysis	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Imposed ingredient constraints	N	N	Y	N	Y	Y	Y	Y	Y	N	N
Imposed nutrient constraints	N	N	Y	N	Y	Y	Y	Y	Y	Y	N
Ration cost analysis	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ration mixing/loading weights	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Blended ingredient mixing weights	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Blended ingredient nutrient profile	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Multiple ration comparison	N	N	N	N	Y	Y	Y	Y	N	Y	Y
Feed inventory or usage	N	Y	N	N	N	N	N	Y	Y	N	N

[a]CPMD = CPM Dairy, ODRP = Ohio Dairy Ration Program, Spartan = Spartan Ration Evaluator/balancer, Brill = Brill Formulation, DMax = DairyMax, DRSII = Dairy Ration System II, DRSW = Dairy Ration System for Windows, Form2 = Formulate2, RtnPro = RationPro, TCN = The Consulting Nutritionist.

Surprisingly, several commercial programs (DRSW, Form2, RtnPro and TCN) did not provide for reporting of shadow pricing for ingredients used. Moreover, neither Form2 nor TCN provided opportunity pricing for ingredients not used. This information can be important in making commodity-purchasing decisions and should be included as part of the reports package and not just for on-screen display.

Summary

Because a variety of software applications for formulating dairy rations are available, selection of an appropriate program can be frustrating and time consuming. As with any type of software search, the user should begin assessing software needs by listing the important program functions and capabilities desired.

All DOS software versions reviewed are highly compatible within the Windows environment and most of the companies have indicated that Windows versions of their products were either under development or scheduled for release. The 1989 NRC provides the foundation for most programs and brings some commonality to the software available. All software programs incorporate some type of ration evaluation option within their software package. After that the programs vary in complexity. Most software packages provide for formulation of rations at least cost; however, a few also contain other objective functions. These may include a profit-maximizing function as well as functions to allow for optimization of the use of certain ingredients, such as homegrown feeds, while minimizing purchased feed costs. Still other items such as the report writing, economic analysis, diagnosis of infeasible solutions, and overall flexibility of the program are important and vary considerably among the programs evaluated.

Overall, private industry software products allow for more flexibility and user input than the university developed software. Further, although more expensive, private companies offer services not provided by universities such as software support and training.

References

Bucholtz, H.F. 1997. Variability in chemical composition of commodities. Pages 113-123 in Proc. Tri-State Dairy Nutr. Conf. M.L. Eastridge, ed. Ft. Wayne, IN. The Ohio State Univ., Columbus.

Eastridge, M.L., H.F. Bucholtz, A.L. Slater and C.S. Hall. 1998. Nutrient requirements for dairy cattle of the National Research Council versus some commonly used ration software. J. Dairy Sci. 81:3059.

National Research Council. 1989. Nutrient Requirements of Dairy Cattle. 7th Ed. National Academy Press, Washington, D.C.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th Ed. National Academy Press, Washington, D.C.

Roseler, D.K., D.G. Fox, L.E. Chase, A.N. Pell and W.C. Stone. 1997. Development and evaluation of equations for prediction of feed intake for lactating Holstein dairy cows. J. Dairy Sci. 80:878.