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Veterinarians and dairy nutrition management: basic concepts and design-it-yourself—a veterinary-oriented ration evaluation program

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Summary

Veterinarians increasingly play a major contributory role in dairy practice and management. With increasing importance of economical pressures, bioenvironmental limits and increasing demand for higher quality products, veterinarians are more involved in nutrition management and advice, both from an economical view of productivity and preventive aspects of veterinary medicine. The concept of food animal production medicine is the hallmark of such a change from purely diagnosis and treating sick cows to design strategies for disease prevention and economical profitability. One of the essential parts of the new role is to have a good command of nutritional concepts and acquaintance with ration formulation procedures and also softwares. It appears that the available ration formulation softwares are insufficient in view of estimating necessary criteria for dairy practitioners. Moreover, the release of new edition of NRC and subsequent modification of software programs for ration formulation always lag behind the generation of new knowledge in dairy nutrition. This article describes the basic nutritional concepts, as well as a practical approach to design a ration evaluation program based on Microsoft® Excel. The program can be designed in a profession-oriented approach.

Key words: Spread sheet, Ration evaluation, Dairy cattle

Introduction

Until the early 1960s, veterinarians in food animal practice devoted most of their time to treat and manage sick animals. However, a new trend has been emerged; dairy practitioners have been exploring ways to prevent diseases rather than taking the time- and effort-consuming process of prescription and treatment (Jarret, 1988). Veterinarians increasingly play an important contributory role to the profitability of dairies by providing nutritional advices.

When veterinarians confront with one of diseases associated with inadequate or mismanaged nutrition, e.g., ketosis, hypocalcemia, displaced abomasum, and ruminal acidosis (acute and subacute), they should not only treat the affected cow(s) but should detect the causative managerial/nutritional failure and follow the relevant corrective measures in the farm.

Diseases associated with nutrition will emerge in a dynamic process; each may be the result of long-term nutritional imbalances and may be the tip of an iceberg. Sometimes, minor but long-standing nutritional imbalances may drive a marginally-deficient animal or herd into a major problem.

With increasing level of production, the margin of health and disease is going to become narrower, and a typical veterinarian must be equipped with a good knowledge of nutrition, to handle a herd properly.

There are increasing overlaps in dairy practice management in terms of disease prevention and dietary management. No doubt, there is some potential points of stalemate or conflict in the attempt to resolve a herd problem such as ketosis and ruminal acidosis and each of the veterinarian or the nutrition advisor takes its own way according to their own presumptions (Nordlund *et al.*, 1995). Nowadays, with many large dairy herds, a teamwork that consists of a veterinarian, a nutritionist and multiple outside consultants are used, and a team approach provides high level of expertise. In many herds the veterinarian is best suited to be the “team leader” (Gerloff, 2001). So, the veterinarian must be equipped with a reliable source of information to perform his leadership role satisfactorily, and minimize the level of conflict and overlap with nutritionists and consultants in a teamwork setting.

There are several ration formulation softwares that are used extensively in dairy practice, as well as other fields of food animal production. However, from the standpoint of diagnostic evaluation of the problematic rations, these softwares may not be designed to perform calculations to respond to all of the requirements of a veterinarian, practicing in food animal production medicine. Microsoft® Excel has the potential of being a companion to all of well-known ration formulation programs, with a veterinary-oriented approach. This article tries to suggest a simple and precise way for rapid evaluation of rations from a diagnostic and analytical viewpoint.

Methodology of design-it-yourself

Veterinarians may encounter situations that need a thorough analysis of the ration with respect to diagnostic challenges. For example, the energy status in the case of infertility, or the calculation of fiber related criteria in the case of chronic rumen acidosis and milk fat depression. The NRC 2001 has been chosen as framework. Please consider Table 1 which evaluates a typical ration for a representative mature lactating cow weighing 700 kg, producing 45 kg (3.5% fat) milk per day; and requires 26.9 kg dry matter intake (DMI), 43.1 kg net energy of lactation (NEL), 17.3% crude protein (CP), 1.95 kg rumen undegradable protein (RUP) (7.2% of DMI), 2.71 kg rumen degradable protein (RDP) (10% of DMI), 25–33% neutral detergent fiber (NDF), 17–21% acid detergent fiber (ADF), 0.6% absorbable calcium (Ca), and 0.38% absorbable phosphorus (P).

This is my way to construct a ration evaluation program using the Microsoft® Excel program. In the first column of Table 1, the names of feeds and ration evaluation criteria will appear. In the second row, one can put the principal components of a ration formulation process, in its simplest form. They include the amount As-fed, DMI, CP, RUP, NDF, non-structural carbohydrates (NSC), Ca, P, crude fiber (CF), ether extract (EE)—all in kg; NEL in megacalories (Mcal), the amount of each feed component in one ton of the concentrate (tonnage).

In rows 5 to 21, each component of the ration appears and its share in the providing of various nutrients will be calculated. Here, we consider the calculations only for corn silage, as an example.

According to the As-fed column, for example, each cow receives 24 kg of corn silage per day. We put 24 in the *C5* cell. Then calculate the following cells in the row 5 according to Table 2.

The same calculations can be conducted for other feedstuffs according to their nutritive values.

In row 22 of Table 1, the sums of nutritive values of feedstuffs can be calculated. For example, in row 22, the sum of the As-fed column cells is calculated by the following formula: *=C5+….+C21*; or simply by insertion of the sum icon (Σ) at the menu bar and highlighting the related cells by mouse (in this example, *C5-C21* cells), followed by striking the <ENTER> key. The same calculations can be performed for the NEL, CP, RUP, NDF, NSC, Ca, P, CF and EE in the cells *D22* to *N22* and *O22* cells, respectively. Now, useful calculations for extracting important clinical criteria can be performed in Table 3 as follows (according to Table 1):

Energy and carbohydrate contents

It must be taken into consideration that daily fat-corrected milk yield entered in the ration evaluation/balancing equation should be for the target percentile cow, not the average cow. The rationale for this recommendation is that the foregone income from milk sales from underfeeding a cow, failing to meet the cow’s nutrient requirements, will always be greater than the extra feed cost of slightly to modestly overfeeding her (VandeHaar and Black, 1991). Microsoft®

Table 1: The components of the ration evaluation program in Microsoft® Excel

1	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2														
3		As-fed	DMI	NEL	CP	RUP	NDF	NSC	Ca	P	CF	ADF	Tonnage	Fat
4														
5	Corn silage	24.00	7.20	10.08	0.58	0.19	4.82	0.55	0.02	0.01	1.51	2.02		0.15
6	Alfalfa hay	5.00	4.50	5.54	0.68	0.19	1.87	1.17	0.06	0.01	1.31	1.58		0.09
7	Wheat straw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
8	Ground barley grain	3.75	3.44	6.67	0.45	0.11	0.52	2.31	0.00	0.01	0.14	0.31	220.59	0.07
9	Ground corn grain	1.80	1.62	3.17	0.15	0.10	0.19	1.15	0.00	0.00	0.04	0.05	105.88	0.07
10	Wheat bran	2.00	1.83	2.59	0.28	0.04	0.92	0.42	0.00	0.02	0.21	0.28	117.65	0.08
11	Sugar beet pulp	2.10	1.92	3.44	0.19	0.07	0.96	1.92	0.01	0.00	0.32	0.48	123.53	0.01
12	Cotton seed meal	2.20	2.00	3.58	0.85	0.30	0.60	0.36	0.00	0.02	0.28	0.38	129.41	0.03
13	Cotton seed	2.00	1.84	4.10	0.42	0.14	0.81	0.13	0.00	0.01	0.44	0.63	117.65	0.37
14	Soybean meal	2.00	1.84	3.39	0.83	0.30	0.11	0.68	0.01	0.01	0.12	0.18	117.65	0.03
15	Fat powder	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Limestone	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	11.76	0.00
17	Dicalcium phosphate	0.20	0.19	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.00	11.76	0.00
18	Sodium bicarbonate	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.71	0.00
19	Magnesium oxide	0.13	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.35	0.00
20	Salt (NaCl)	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.35	0.00
21	Trace mineralized salt	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.71	0.00
22	Total	46.00	27.35	42.57	4.43	1.44	10.81	8.69	0.23	0.14	4.37	5.90	1000.00	0.91
23		kg	kg	Mcal	kg	kg	kg	kg	kg	kg	kg	kg		
24	Forage (kg)	29.00	11.70		ADF%DM		21.56		Moisture%		40.55			
25	Concentrate (kg)	17.00	15.65		NSC%DM		31.78							
26	Forage % of body weight		1.67		Ca%DM		0.84		RDP kg		2.99			
27	Concentrate % of body weight		2.24		P%DM		0.52		RDP/CP%		67.48			
28	Forage % of DM		42.78		Ca/P		1.62							
29	Concentrate % of DM		57.22		Crude fiber%		15.99							
30	NEL/kg of DM		1.56		NaHCO3%DM		0.91							
31	NEL/kg of concentrate (DM)		1.72		MgO%DM		0.45							
32	Forage NDF (kg)		6.70		Salt%DM		0.48							
33	Concentrate NDF (kg)		4.11		EE%DM		3.32							
34	Forage NDF % of DM		24.49		CP%		16.19							
35	Forage NDF % of total NDF		61.97		RUP/CP%		32.52							

Table 2: Putting the formulas for evaluation of nutritive value of corn silage (as an example)

Criteria	Original cell and multiplication factor	Product of multiplication	Destination cell
DMI	=*C5**30%	7.2 kg	*D5*
NEL	=*D5**1.4 Mcal	10.08 Mcal	*E5*
CP	=*D5**8.1%	0.58 kg	*F5*
RUP	=*F5**33%	0.19 kg	*G5*
NDF	=*D5**67%	4.82 kg	*H5*
ADF	=*D5**28%	2.02 kg	*M5*
NSC	=*D5**7.6%	0.55 kg	*I5*
Ca	=*D5**0.34%	0.02 kg	*J5*
P	=*D5**0.19%	0.01 kg	*K5*
CF	=*D5**21%	1.51 kg	*L5*
EE	=*D5**2.1%	0.15 kg	*O5*

Table 3: Criteria for ration evaluation, formulas, actual concentration in the ration and destination cells in spreadsheet. requirements/recommendations are presented for comparisons

	Criteria		Calculations according to related cells (left) and destination cell (right column)		Actual concentration in the ration	Requirement/ recommendation (minimum)
1	Forage	As-fed (kg)	=SUM(*C5:C7*)	*C24*	29 kg	
2	Forage	DM (kg)	=SUM(*D5:D7*)	*D24*	11.7 kg	
3	Forage	% of Body weight	=*D24**100/700	*D26*	1.67%	*1.5%*
4	Forage	Forage DM/total DM	=*D24**100/*D22*	*D28*	42.78%	*40%*
5	Concentrate	As-fed (kg)	=SUM(*C8:C21*)	*C25*	17 kg	
6	Concentrate	DMI (kg)	=SUM(*D8:D21*)	*D25*	15.65 kg	
7	Concentrate	% of body weight	=*D25**100/700	*D27*	2.24%	*2.3%*
8	Concentrate	% of concentrate/DMI	=*D25**100/*D22*	*D29*	57.22%	*60%*
9	Concentrate	NEL/kg of concentrate (DM)	=(*E8+…+E21*)/*D25*	*D31*	1.72 Mcal/kg	
10	NEL/kg of DM		=*E22/D22*	*D30*	1.56 Mcal/kg	
11	CP	% in the diet (DM)	=*F22**100/*D22*	*H34*	16.19%	*17.3%*
12	CP	RUP/CP%	=*G22**100/*F22*	*H35*	32.52%	*35%*
13	CP	RDP (kg)	=*F22-G22*	*L26*	2.99 kg	*2.71 kg*
14	CP	RDP/CP%	=*L26**100/*F22*	*L27*	67.48%	
15	NDF	Total (kg)	=SUM(*H5:H21*)	*H22*	10.81 kg (39.52% DM)	*25-33% DM*
16	NDF	Forage NDF (kg)	=SUM*(H5:H7)*	*D32*	6.7 kg	
17	NDF	Forage NDF/DM (%)	=(*H5+H6+H7*)*100/*D22*	*D34*	24.49%	*19%*
18	NDF	Forage NDF/total NDF (%)	=*D32**100/*H22*	*D35*	61.97%	
19	NDF	Concentrate NDF (kg)	=SUM(*H8:H21*)	*D33*	4.11kg	
20	ADF (%) of DM		=*M22**100/*D22*	*H24*	21.56%	*17-21%*
21	CF (%) of DM		=*L22**100/*D22*	*H29*	15.99	*17%*
22	NSC (%) of DM		=*I22**100/*D22*	*H25*	31.78	*35%*
23	Ca (%) of DM		=*J22**100/*D22*	*H26*	0.84	*0.6%*
24	P (%) of DM		=*K22**100/*D22*	*H27*	0.52	*0.38%*
25	Ca/P ratio		=*J22/K22*	*H28*	1.62	*1*
26	NaHCO3 (%) of DM		=*D18**100/*D22*	*H30*	0.91	
27	MgO (%) of DM		=*D19**100/*D22*	*H31*	0.45	
28	Salt (%) of DM		=*D20**100/*D22*	*H32*	0.48	
29	Ether extract (EE) %		=*O22**100/*D22*	*H33*	3.32	*Maximum 6-7%*
30	Moisture (%)		=(*C22-D22*)*100/*C22*	*L24*	40.55	

Excel can also calculate the desired percentile instantly.

The concentrations of energy and carbohydrate in the total ration and in the concentrate are the other aspects of evaluation of energy status in the ration that can be compared to the desired targets.

The starch content of diets for early lactating cows may be >35% of DM. Non-fiber carbohydrate (NFC) is an estimate of NSC and can be calculated as NFC% = 100% – (CP% + NDF% + EE% + Ash%). This will provide a reasonable estimate of NSC for feeds low in pectin and gums (Allen, 1991).

Cows in early lactation, generally require more energy than they are able to consume and must therefore mobilize body energy reserves for milk production. Increasing the energy density of the diet by feeding more grain, often results in the declined energy intake and more condition loss. Consequently, suboptimal energy intakes occur due to failure of maintaining an optimal rumen movements and environment following both insufficient fiber and excess NSC. With this regard, feeding more grain to thin cows, of course, makes matters worse (Allen, 1991; Grove-White, 2004). Microsoft® Excel, as illustrated in Table 3, can design more pertinent calculations. According to Table 1 and row 22 in Table 3, there is evident that some degrees of deficiency is present in the supplied NEL (43.1 required vs 42.57 supplied) and NSC (35% required vs 31.78% supplied) of the typical ration. So, the veterinarian can suggest some advice in this regard.

Protein contents

A veterinarian must be ware that the food intake, in most experiments, was about 2% of body weight (BW). High-producing dairy cows consume food at 3 to 4% of BW. Since the passage rate of food ingredients increases as food intake increases, ruminal RUP of protein is probably greater than values suggested by NRC 1989 (Chalupa and Sniffen, 1991). Thereby, it may be advisable to consider some extra-RUP especially in the ration of high-producing cows. However, requirements for RDP, RUP, and total protein are dependent on animal factors, the concentration of available energy in the diet, and DMI intake (NRC, 2001). According to Table 1 and rows 11–13 in Table 3, there is some deficiency in absolute and relative amounts of protein contents of the ration. (17.3% required CP vs 16.19% supplied; 1.95 kg required RUP vs 1.44 kg supplied). In contrast, RDP is sufficient.

Metabolizable protein (MP) is defined as the true protein that is digested post-ruminally and the component amino acids absorbed by the intestine. Amino acids and not protein *per se*, are the essential nutrients (NRC, 2001). With Microsoft® Excel, you can design the column of protein requirement according to MP and even calculate the amount of every amino acid provided by the ration and calculate the deficit or surplus.

Fiber contents

In the past, this requirement was measured in terms of forage to concentrate ratio (F:C). Because the fiber contents of forages is extremely variable, many nutritionists have switched from balancing rations based on F:C systems that directly measure the fiber content of the diet. Which measure of fiber to be used when balancing rations is controversial. Most nutritionists have abandoned CF because it is inconsistent across foods. Moreover, during CF estimation procedure, part of lignin and part of hemicellulose will not be measured (Allen, 1991).

NDF measures the fiber fraction consisting of hemicellulose, cellulose, and lignin. Pectin is not recovered in the NDF fraction. ADF measures a fraction of fiber consisting mainly of cellulose and lignin. NDF and ADF are rapid and repeatable measures of fiber that are routinely used for balancing rations. Of the two, NDF seems to be more suitable for determining fiber requirements. However, the requirement for fiber involves both the chemical and physical properties of foods as well as physiologic and behavioural aspects of the cow (Allen, 1991). Not to be forgotten that the effective NDF (eNDF) is the fiber in the ration that enhances rumination and rumen motility. (Hall, 1999; Grove-White, 2004). It is recommended to provide at least 25% of DM as NDF, with the condition that 19% of dietary DM must be NDF from forage, in rations with alfalfa or corn silage as the predominant forage and dry ground corn as the predominant starch source (NRC, 2001).

Another important application of ADF is to calculate acid detergent insoluble protein (ADIN) (Chalupa and Sniffen, 1991) that may have an important effect on our prediction of production, when forages contain large amounts of ADF. In this regard, the typical ration contains surplus amounts of fiber. The veterinarians must be aware that excessive fiber may decrease the energy concentration in the ration with inevitable subsequent decline in production due to suboptimal energy intake.

The minimum percentage of forage in the ration (at least 40% of DMI), maximum percentage of concentrate in the ration (60% of DMI), maximum percentage of concentrate to the BW (maximally 2.3% of live weight) (Linn *et al*., 1989), and minimum percentage of forage to BW (e.g., 1.5% of live weight) are not parameters as precise as NDF. However, they can be regarded as safety measures along NDF, especially, when the calculations are based on tables of composition of food, in spite of the results of proximate analysis. All of these measures have been met in the typical ration.

Fat contents

One-half of the milk fat must come from dietary fat. The typical ruminant diet contains about 3.5% crude fat or EE. Crude fat may be from 50% to as much as 90% fatty acids, depending on the source. High-producing cows frequently lack the fatty acids required for normal milk production. It is indicated to add extra-calcium and magnesium to diets that are supplemented with fat. The transfer of dietary fat to milk fat is energetically more efficient than synthesis of milk from acetic acid. Thus, dietary fat is essential for synthesis of part of the milk fat and is more efficient than synthesis of new fatty acids. (Emery and Herdt, 1991). In most situations, total dietary fat should not exceed 6–7% of the diet (NRC, 2001). In a typical ration, some fat can be included and the veterinarian must advise it; but at the same time, she/he must take it into consideration that the present deficiency of the typical ration with regard to RUP may be exacerbated due to added fat.

Cows frequently mobilize large amounts of fat during the first few weeks of lactation. This amount of fat can supply enough energy to make an extra 4.5 to 5.5 kg milk per day for 60 to 90 days. It is important to supply enough RUP to balance the energy mobilized from adipose tissue. Theoretical calculations suggest that 0.3 unit of extra-ruminally undegraded protein should be fed for each unit of fat added to ration. Although the amino acid composition of the ruminally undegraded protein should be considered, with special attention to ruminally protected lysine and methionine (Emery and Herdt, 1991). It is previously stated with regard to MP that calculation of the amount of a variety of amino acids is crucial and can be done by Microsoft® Excel easily.

Some practical and empirical parameters

Other potentials of this approach are to calculate the share of every food stuff in every ton of concentrate, as it appeared in Table 1. The components of each ton of concentrate have appeared in the cells *N8* to *N21*. Similarly, the price of total ration or every kg of the ration or the concentrate can be calculated. When considering feeding programs, nutritional consultants commonly communicate in a complex subdialect of numbers. Usually, these numbers are some proportion of the ration. For example, they might refer to 1.65 Mcal/kg, or 17% protein, or 40 ppm of manganese. Each of these numbers is a proportion, usually of DMI. Ratios are also commonly used, for example, a 40:60 ratio of forages to concentrates or 3:1 ratio of vitamin A to vitamin D. Proportions and ratios are useful shorthands for communication, but keep in mind that the cow's requirements are not satisfied by balanced ratios. The cow requires absolute amounts of each nutrient. She requires total Mcal's of energy, kg's of protein, and mg's of manganese. Proper proportions in a diet satisfy the cow's requirements only if her total DM is adequate. If she eats too little of a "balanced" ration, her requirements remained unfilled (Gerloff, 2001).

Some prominent characteristics of this approach

As stated previously, even advanced softwares may not calculate some important parameters for a practicing veterinarian. For example, chlorine is missing from many ration-balancing programs (Beede, 1991). Exceptionally, Spartan considers chlorine.

Some preventive nutritional measures can be part of your Microsoft® Excel program for ration evaluation. For example, dietary cation-anion difference (DCAD) for close-up pregnant cows can be calculated easily. Interestingly, you can choose your desirable equation for that from the following formulas or even all of them. This maneuverability seems to be unique to Microsoft® Excel:

DCAD (meq) =(Na+K+0.38Ca+0.30Mg)-(Cl+0.60S+0.50P)

DCAD (meq) =(Na+K)–(Cl+S)

DCAD (meq) =(Na+K)–(Cl) (Oetzel, 2000; Oetzel, 2003)

Monitoring DCAD is not limited to close-up lactating cows. High DCAD diets in early lactation of almost 400 meq/kg have shown to be beneficial (West *et al.*, 1991; Sanchez *et al.*, 1994).

You can change the composition of food stuffs in your program according to the laboratory results. In other words, the calculating formulas can be changed as you wish.

The evaluation of rations can be managed during your routine visit of farms. No need to return to home and staying exhaustive times behind your computer.

Toxicological evaluation of the ration is another important capability of this approach. For example, you can estimate the amount of toxic components of the ration and compare them with safety measures. This approach is very important in cases where rapid diagnosis is required in cases of outbreak of toxicities, e.g., urea-induced ammonia toxicity and nitrate poisoning, which bear the potential of inducing acute severe toxicities. On the other hand in cases of chronic toxicities, e.g., gossypol toxicity, salt poisoning and various mineral toxicities, you can estimate the potential danger. This feature is unique to this approach, but is an independent chapter and won't be considered further in this text.

Some important notes

There must be a good command on both Microsoft® Excel and more importantly on basic concepts of nutrition. Without that, any effort is worthless.

The veterinarians must estimate what is happening within the cows' body and on farm. Nutrition concepts follow their dynamic process (e.g., DMI, RUP, MP, etc.). However, our calculations may follow a static process. So, a keen veterinarian should apply these static calculations in a dynamic management process. For example, important monitoring parameters are particle separation, milk butter fat, milk urea nitrogen and milk protein (Seglar, 1997). Ruminal pH, serum β-hydroxybutyrate, plasma non-esterified fatty acids, reproductive performance, physical examination of faeces, forage length, behavioural response of cows, and other relevant criteria can also be used as monitoring indices as well (Oetzel, 2003). It is strongly recommended to refer to excellent articles in this subject. (Seglar, 1997; Hall, 1999; Oetzel, 2003; Grove-White, 2004)

You may use Microsoft® Excel as a companion and complementary to your favorite ration balancing software. With Microsoft® Excel, veterinarians would enjoy information to deal with nutritionists more effectively.

This approach is a valuable instrument when one performs metabolic profile analysis of the herd and concurrent ration evaluation.

Veterinarians typically, have immediate interrelationship with the cows and are more aware of the metabolic and nutritional diseases that can affect a given dairy farm productivity. Finally, most veterinarians enjoy a high degree of respect by their clients and thus have greater opportunity to execute the art of nutrition management (Jarret, 1988). With this approach, we can manage our leadership role in the food animal production medicine with great efficiency.

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