Spartan Dairy 3: Update and Application to Brazilian Dairies

Michael J. VandeHaar and Luis Felipe Prada e Silva
Michigan State University and University of Sao Paulo at Pirassununga

The Spartan Dairy Ration Evaluator/Formulator version 3 was released publically in the summer of 2010. Spartan Dairy 3 is a stand-alone Windows program that uses a spreadsheet interface, similar to Spartan 2, but it is a complete remake of the program with many new features and a completely new nutritional model and user interface. The team working on Spartan Dairy 3 includes Mike VandeHaar, Robert Kriegel, Dave Beede, Herb Bucholtz, and Mike Allen. Information about the program can be found in our help manual, and on our website, www.spartandairy.msu.edu. From this website, you can download a free fully-functioning demonstration version for testing. The program sells for USD450. Spartan Dairy 3 was designed to formulate reasonable diets in a relatively short period of time using the latest proven science that can be applied to equations. Spartan Dairy 3 is a 32-bit Windows application that runs on Windows 8, 7, Vista, or XP. It operates like many other Windows applications. In version 3, we have tried to retain those aspects of Spartan Dairy 2 which made it successful, while also incorporating the best science for on-farm nutrition. The nutrition model is based largely on the 2001 version of the Nutrient Requirements of Dairy Cattle by the National Research Council (NRC 2001), but incorporates additional nutritional changes developed at Michigan State University. Spartan 3 has its own unique system for predicting intake and nutrient requirements, and for balancing fiber and energy. The energy and protein systems of the 2001 NRC can be monitored. The program has about 120 feed characteristics to help with nutrition trouble shooting, but a diet can be balanced relatively easily with only about ten of these. Spartan 3 includes the ability to open multiple rations and feed libraries at once, graphics to display nutrient adequacy, movable columns, options for metric or pounds, and ease in copying and pasting feeds between files and with MS Excel. Estimates for excretion of N, P, and K can be reviewed to enhance environmental sustainability and help plan farm nutrient management plans. Reports can be previewed before printing. The program has been used successfully on farms and in teaching for 5 years and on farms for 3 years.

In this paper, we will explain: 1) the philosophy of ration formulation/evaluation that underlies the program, 2) key components of the nutrition model, 3) how to use the program, and 4) application of using the program in Brazil.

THE PHILOSOPHY UNDERLYING SPARTAN 3

Although Spartan Dairy 3 is a computer ration balancing program that is based on a nutrition model, our basic philosophy starts with the premise that all models and computer ration programs are seriously flawed. The “ration balancer” is the person. The program is a useful tool, but it is based on a nutritional model that is a series of mathematical equations. These equations try to match up nutrient requirements of the animal with nutrient supply from the feeds. Implicit in any nutrition model is the ability for us to quantify all the important characteristics of feeds and mathematically define how the animal will respond to them. This ability has been oversold!

First, it is difficult to measure all of the characteristics of feeds that are critical in balancing rations (Table 1). We can measure fiber, N, fat, and a few other nutrients, but we cannot accurately predict the fraction of fiber that will be digested, the fraction of protein that will be degraded in the rumen, or the fraction of carbohydrate that will be fermented in the rumen. These are all key to predicting the energy available from a diet and the protein that will be absorbed, and the regulation of apetite and partitioning.

Second, it is difficult to accurately predict animal responses. Most programs assume that we know how much a cow will eat and produce before the diet is fed and do not even attempt to predict how a diet will alter feed intake or partitioning of nutrients. Moreover, predictions of the flow of microbial protein to the small intestine are often inaccurate even when we know feed intake. We also assume that the efficiencies of converting the energy or protein in a feed to milk or body tissues can be accurately predicted. Then we balance rations to meet a target milk production at a target intake assuming we know conversion efficiencies. However, diets high in fat or indigestible fiber often will decrease feed intake and high starch may alter partitioning. Intake and partitioning responses are difficult to accurately model because they are affected by several factors, including type of fat or fiber or starch, particle size, stage of lactation, environment, and interactions of these factors. Thus, it is the person, not the computer, who must decide how much fat is too much, how much fiber is optimal, and how much undegradable protein supplement is optimal for profitable milk production.

Table 1. Important animal and feed characteristics for evaluating and balancing diets

Important characteristics that can be accurately measured but often are not	Important characteristics that cannot be accurately measured or predicted
• body weight, body condition, milk production, feed intake, and diseases incidences of cows and actual responses in these variables to diet changes • %dry matter, %neutral-detergent fiber, %crude protein, %lignin, %Ca, P, and other minerals, and particle size of feeds	• how the diet will alter intake • the percentage of fiber, protein, and starch that will be digested in the rumen and total tract • how the diet will alter milk production and partitioning of nutrients • how the diet will alter the amount of protein absorbed and its amino acid composition

Third, it is easy to be precise using mathematical equations, and precision gives the false impression of accuracy! In ration balancing, precision is the repeatability of a result, whereas accuracy is degree to which the result is true (Figure 1). For example, if we use the 2001 US Dairy NRC to balance a diet for a cow producing 45 kg of milk using typical Michigan feeds, the model will almost always show that methionine is deficient in diets that are 17%CP. However, when the diets are actually fed, responses to supplemental methionine are not consistent. The fact that the model will repeatedly say the supplement is needed, but that the cows show it to be wrong, means that it is precise but inaccurate.

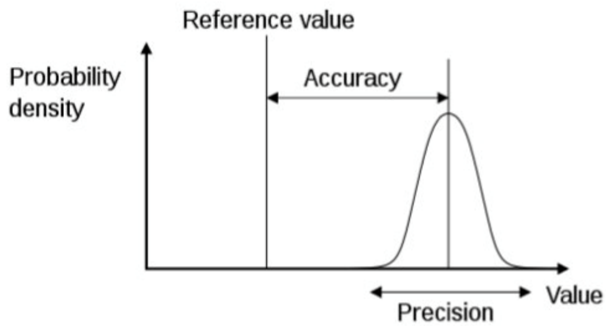


Figure 1. Accuracy vs precision. Accuracy for a model result is its proximity to the true reference value, whereas precision is the repeatability of the model result. In modeling, it is generally easy to be precise; being accurate (within 2% of the real value) is much harder.

Fourth, models by their nature, lure people into wasting time getting the numbers perfect on a computer screen instead of doing the hard work of quality in feeding and monitoring cows. Most nutrition models are based on strict requirements for a nutrient rather than response functions (Figure 2). Thus, for example, we try to provide enough metabolizable protein to meet an exact requirement, when in fact, slightly less would make very little difference to the cow because she responds to increasing protein with a diminishing response. Moreover, we feed cows in groups and their responses vary, but we balance for a target animal who represents the average, or perhaps the top end. Therefore we have nutrient requirements and feed nutrient values set with several significant figures beyond their accuracy, and the temptation is to try to match these up perfectly. The computer diet becomes the focus and takes away from time that could better be spent monitoring cows. In the end, the cow can tell us what is the best diet, but it takes effort and time to monitor cows and feeding programs. It is not reasonable to spend much time balancing for protein fractions or amino acids if time is not spent controlling quality in accurately weighing and mixing feeds, adjusting amounts of wet feeds for changes in moisture content, ensuring feeds are not spoiled, ensuring feed is available when cows want to eat it, and ensuring the environment is comfortable.

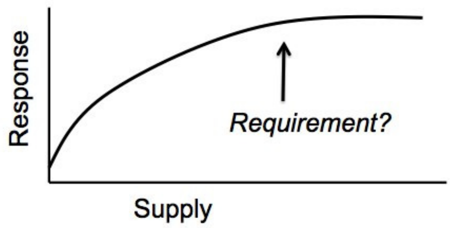


Figure 2. Nutrient requirements vs nutrient responses. Many models, including NRC and Spartan 3, calculate precise requirements for most nutrients to meet needs for maintenance and milk, but in actual feeding the production of milk responds to nutrient supply following the law of diminishing returns. There is no exact “requirement”.

Our idea with Spartan 3 was to provide a tool so that a reasonable diet could be formulated relatively quickly. Our goal was to enable nutritionists to spend more time controlling quality of the feeding program than formulating computer diets. We also wanted a model that was reasonably resistant to mistakes in data entry (for example, mistakes in entering a digestion rate should be obvious), was transparent, and was easy to use.

KEY COMPONENTS OF THE NUTRITION MODEL.

Spartan 3 includes the energy and protein system of 2001 NRC, some parts of the 1989 NRC, and a modification of NRC, which we call the Spartan 3 model or system. Some of the more important modifications from NRC are:

- More emphasis is placed on minimizing fiber and less is placed on meeting NEL requirements for high-producing cows.
- More emphasis is placed on CP, and less emphasis is placed on metabolizable protein (MP) and amino acids. In Spartan 3, CP and MP are given equal importance.
- The calculations to predict NEL supply were altered so that, compared to NRC, Spartan 3 depresses digestibility less and gives starch more value relative to protein and fiber for high producing cows. We do not use lignin to automatically calculate fiber digestibility.
- The calculations to predict MP supply were also altered slightly. Most importantly the requirement for rumen-degraded protein was decreased.
- Mineral and vitamin requirements per unit DM are never less for high than low producers.
- Temperature and activity alter requirements by categories rather than precise equations.

Evaluation vs Formulation models. NRC 2001 was built as an evaluation model, but Spartan 3 was built as a formulation model. The difference is subtle but important. The goal of NRC is to evaluate if nutrient intake matches nutrient output. The goal of Spartan 3 is to enable the design of a reasonable blend of feeds with optimal nutrient concentration, usually for ad libitum intake. In an evaluation model, feed intake, milk yield, and diet recipe are already known; we already know that the diet must be at least reasonable as the cows are eating it and producing milk. In a formulation model, we can estimate feed intake but we are just trying to design a diet recipe that has a reasonable nutrient concentration. The person running the program is key and must have an idea of what is reasonable.

Dry matter intake (DMI). Spartan 3 uses a unique equation to predict how much a cow will eat. The prediction is reasonably accurate for commercial farms in Michigan. However, it is still only a prediction and it is not based on feed factors. The prediction assumes that cows are in a comfortable environment and being fed reasonable diets—adequate protein, low in fat, and with fiber at levels typical for the stage of lactation—in intensive feeding systems. Accurate information on how much cows actually eat is invaluable in managing cows to produce milk efficiently and profitably, but this equation provides a starting point to design the blend of feeds. In Spartan 3, the DMI prediction is similar to that of 2001 NRC, but uses metabolic BW for maintenance requirement of all animal classes and uses 0.45 x milk energy rather than 0.37 x 4%FCM for milk requirement. The DMI prediction also includes a component for BW gain, is adjusted around calving similar to NRC, and can be adjusted for temperature and activity.

Fiber. Feeding just enough fiber to meet requirements for a healthy rumen is generally consistent with optimal production, health, efficiency, and profitability. In Spartan 3, we use NDF, effective NDF (efNDF), and forage NDF (forNDF) and recommend that two of these fiber measurements exceed requirments. Typical minimum fiber concentrations for lactating cows are: 27% NDF, 20% forNDF, and 22% efNDF with all feed fiber considered to be 25 to 100% effective. Thus, if most of the dietary fiber is from forages, the diet should be ~27% NDF; if the diet has a lot of high fiber byproducts with short particle size, the diet should be at least 30% NDF.

Energy. The Spartan 3 energy system is a modification of NRC 2001. Requirements are from 2001 NRC but adjusted for temperature and activity. As in 2001 NRC, the NEL values for feeds are calculated based on their content of fiber, nonfiber carbohydrate, fat, and true protein and the predicted digestibility of each of these components with digestibility depressed at greater levels of intake. We altered these equations to give a Spartan 3 energy value that we think is more accurate. The energy value of protein was decreased, and the digestibility of fiber is no longer tied to lignin. In addition, in contrast to NRC, the digestibility discount of Spartan 3 is not altered by TDN concentration, is higher for short fiber feeds in forage-limiting diets, and the discount per unit of intake diminishes with increasing intake.

For those who want to use a specific energy value predicted by their feed test lab or from a feed composition table, the Spartan 3 or NRC 2001 systems with calculated energy values can be frustrating. Fixed energy values can be used in the program as in Spartan 2 or NRC 1989; however, energy values from feed test labs are also based on equations. We chose equations that we think are relatively accurate and are more specific to each feeding situation, but our predicted energy value is still just an estimate. Spartan 3 enables the 2001 NRC energy values to be monitored so that the differences between the systems can be seen. For high producing cows, we suggest that diets be balanced for minimum fiber with little focus on whether the energy requirement is accurately met.

The basic calculation dependencies in the Spartan 3 system are shown in Figure 3. If users have good reason to think an energy value for a given feed should be higher or lower, they can adjust the digestibility of fiber or some other ingredient until the desired energy value is obtained.

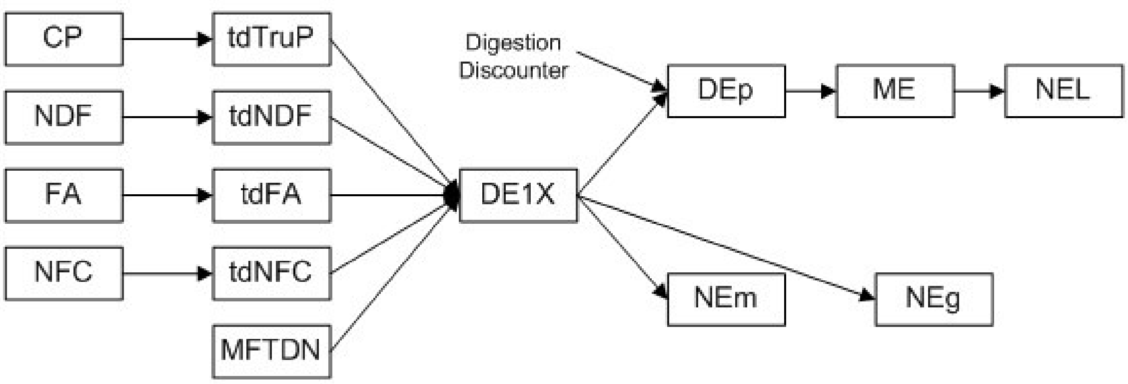


Figure 3. Calculation of energy value for a feed in Spartan 3. Protein, fiber, fat, and nonfiber carbohydrate are each multiplied by a digestibility factor to determine the amount that is truly digested. Then a Digested Energy (DE) value is calculated for a animal fed at its maintenance level intake. Consideration is made for the depression in digestibility as cows eat more feed to estimate DE value at production level, and then the Metabolizable Energy and Net Energy values are estimated.

Protein. The Spartan 3 protein system is nearly identical to that of the 2001 Dairy NRC with only minor changes. As in NRC, the values for rumen undegraded protein (RUP) and rumen degraded protein (RDP) cannot be entered but instead are calculated based on protein fractions (A, B, and C) and the competition of digestion and passage for fraction B. In Spartan 3, the calculated RUP and RDP values for each feed are displayed, so you can make sure the entered fractions and rates give reasonable values. Metabolizable protein supply is similar to 2001 NRC but the RDP requirement is lower. RUP digestibility is included as per NRC. Spartan 3 does include requirements and supply for both lysine and methionine; however, all models are inaccurate for AA, and we recommend that shortages generally be ignored. Instead we recommend that more than one source of RUP be used in a diet for high producing cows.

HOW TO USE THE PROGRAM.

Setting requirements/Describing the target

In Spartan 3, we suggest that the target animal for evaluating or balancing a diet be reasonably close to the average animal in the group. Thus, target milk should be set at or slightly above the average actual yield of milk for a group of cows. Doing this will give a predicted intake that is usually close to the actual intake and give requirements that are average for the group. For cows in early lactation, loss of body condition should also be included so that the concentrations of protein and minerals are reasonable. For cows in early and mid-lactation, we recommend that the diet be balanced for minimum fiber, so choosing a higher target milk than the average has little impact on dietary energy. After balancing or evaluating a diet with the average cow, it is easy to edit the target milk to examine the diet for the top cows in a group. The actual milk yield can be entered but is does not impact requirements and only functions as a monitor.

In Spartan 3, body weight (BW) is described four ways. Total BW is the current BW of a cow if measured on a scale. For pregnant animals, a value is calculated for BW without the mass of tissues associated with pregnancy. If an animal is fat or thin, the weight associated with body condition is estimated, and the non-pregnant body-condition-3 BW gives a better estimate of an animal's true frame size. Finally, the expected BW of the animal at maturity is used to estimate how much BW growth is needed and to estimate the body energy and protein content at a cow's current BW. Current and target values for BW and body condition and days to achieve targets can be edited.

Other factors used to set requirements are environmental temperature, activity level, and feed additives. In Spartan 3, unlike in NRC 2001, no attempt is made to be precise for these effects. Activity level varies from no work to extreme work, and temperature varies from severe cold stress to severe heat stress.

Setting feed characteristics

New feeds. Because Spartan 3 has about 120 characteristics for each feed, we strongly recommened that an existing feed be used as the template. Feeds in the library can be sorted based on NDF or on CP. After finding a feed with a similar composition, it can be edited. Often, the values for many of these characteristics are not reported for the new feed. Using the value from a feed in the library is better than leaving the value at zero. For example, the absorption coefficients for minerals from a grass in the library will be reasonable for those for a tropical forage, and at least better than assuming the absorption is 0%.

Editing feed characteristics. To edit characteristics of a feed based on a feed analysis, the changes can be made in the ration worksheet by simply overwriting the value in the appropriate cell. Another option is the use the **Nutrient Composition** dialog box, which can be opened using the menu. Usually, edits are being made to an existing feed, so only a few nutrients need edits, likely %DM, %NDF, and %CP.

If you are interested in trying to estimate the energy value of a feed as accurately as possible, then you should also check and edit the values for %ash, %EE, and the digestibility coefficients for fiber, nonfiber carbohydrate, protein, and fat. Nonfiber carbohydrate (NFC) is a calculated field and will change as values for ash, fat, NDF, and CP are altered. The digestibility coefficient for protein is a calculated value and the calculation is different than in NRC. Unlike in NRC, the true digestibility of true protein in Spartan 3 is the sum of the rumen-degraded true protein and the digested RUP as a percent of true protein. True protein is crude protein minus any CP from nonprotein nitrogen. In NRC 2001, the true digestibility of fiber is calculated based on lignin; however, this calculation is frequently inaccurate, so it is an entered value in Spartan 3. If lignin is higher than expected based on similar feeds, the NDF digestibility should probably be lowered. Values for in vitro NDF digestiblity from a laboratory are helpful, and the value to use is one from a long incubation (>30 hours). If a feeds energy value seems wrong, and all the measured components seem correct, the easiest way to adjust it is to edit the digestibility of its principal energy source (for example, NDF digestibility for a forage).

If you are interested in using metabolizable protein (MP) to balance for protein, then you should check to make sure that RUP and RDP fields seem reasonable for each feed. These values are calculated based on protein fractions (A, B, C) and the rates of passage and digestion. Fraction A is completely and very quickly degraded in the rumen. Fraction C is not degraded, even after long retention times, and includes protein that is not digestible. Fraction B protein can be degraded in the rumen, and the percentage degraded will depend on its rate of degradation and rate of passage. Rate of passage is a function of feed type, %NDF, and the animals level of intake.

Metabolizable protein supply is a total diet calculation as it is the sum of the absorbed protein from RUP and microbial protein; thus feeds do not have individual values for MP. Microbial protein could be limited by RDP supply, but more likely it is limited by the supply of fermented energy.

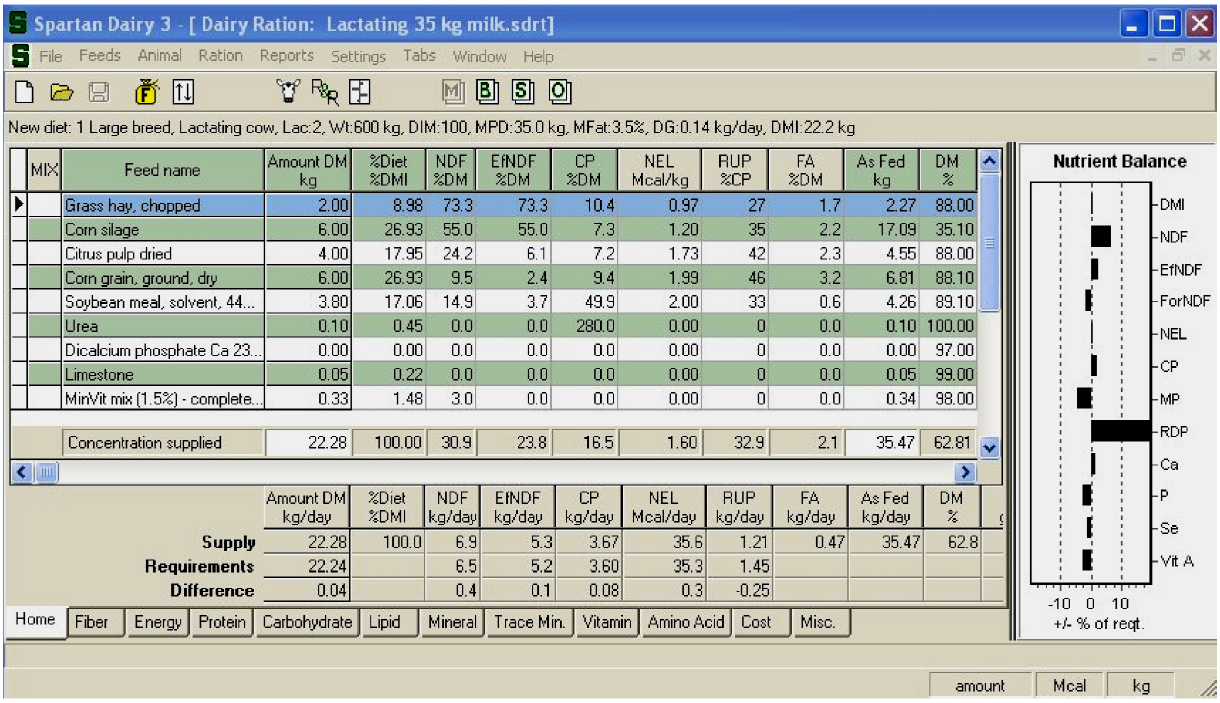
If the %RUP of a feed seems wrong, it can be altered by changing the values for protein fraction B or C or the digestion rate of B.

Commercial feeds. Nutrient composition of most commecial feeds are given on an As Fed basis (usually air-dry, or about 90% dry matter). Feed nutrients in Spartan 3 are all on a dry matter basis. Thus, the values for CP, NDF, and other feed fractions must be divided by 0.9 before entering. Many of the feed characteristics will not be known (for example, digestion rates). One way to develop reasonable values for commercial feeds is to select a few of the major ingredients listed on the feed tag (usually the first three or four) from the library, make a mix of them in equal parts, then copy the mix as a real feed, and finally edit values known to be different. Doing this will help provide better estimates for some of the calculated columns.

Evaluating a diet

To evaluate a diet with Spartan 3, it is critical to properly describe the animal being fed, the feeds being used, and the amount of each feed in the diet. For individual animals, the amounts of each feed can be entered on an as-fed or DM basis. For group-fed animals, the amount of each feed on an as-fed basis consumed by the entire group can be entered in the "GroupAsFed" column. Feed amounts can also be entered as a percentage of the diet. If actual feed consumption is known, it should be used. If the diet is fed as a total mixed ration so that the proportions of each feed are constant, the total amount consumed can be edited by writing a new value over the current value in the "Concentration supplied" row for any of the above columns. A screenshot of a ration is shown in Figure 4.

Nutrient balance graph. The nutrient balance graph shows supply relative to requirements for several feed characteristics. Supply is given as the percentage under or over a requirement. Whether evaluating or formulating diets, the nutrient balance graph can help keep things in perspective so the focus is on what is reasonably close for the major diet characteristics rather than precisely close to the requirement for each nutrient, even those with low degree of accuracy. At the minimum, we recommend the graph to include DMI, NDF, EfNDF, ForNDF, NEL, CP, MP, RDP, Ca, P, Na, Se, and Vit A. The graph can be customized to include more nutrients. These are shown with the most important at the top, with the idea that ration evaluation or formulation be systematic to first examine fiber and energy balance in the context of feed intake, then protein, then macrominerals, micominerals, and vitamins.



MIX	Feed name	Amount DM kg	%Diet %DMI	NDF %DM	EfNDF %DM	CP %DM	NEL Mcal/kg	RUP %CP	FA %DM	As Fed kg	DM %
	Grass hay, chopped	2.00	8.98	73.3	73.3	10.4	0.97	27	1.7	2.27	88.00
	Corn silage	6.00	26.93	55.0	55.0	7.3	1.20	35	2.2	17.09	35.10
	Citrus pulp dried	4.00	17.95	24.2	6.1	7.2	1.73	42	2.3	4.55	88.00
	Corn grain, ground, dry	6.00	26.93	9.5	2.4	9.4	1.99	46	3.2	6.81	88.10
	Soybean meal, solvent, 44...	3.80	17.06	14.9	3.7	49.9	2.00	33	0.6	4.26	89.10
	Urea	0.10	0.45	0.0	0.0	280.0	0.00	0	0.0	0.10	100.00
	Dicalcium phosphate Ca 23...	0.00	0.00	0.0	0.0	0.0	0.00	0	0.0	0.00	97.00
	Limestone	0.05	0.22	0.0	0.0	0.0	0.00	0	0.0	0.05	99.00
	MinVit mix (1.5%) - complete...	0.33	1.48	3.0	0.0	0.0	0.00	0	0.0	0.34	98.00
	Concentration supplied	22.28	100.00	30.9	23.8	16.5	1.60	32.9	2.1	35.47	62.81

	Amount DM kg/day	%Diet %DMI	NDF kg/day	EfNDF kg/day	CP kg/day	NEL Mcal/day	RUP kg/day	FA kg/day	As Fed kg/day	DM %
Supply	22.28	100.0	6.9	5.3	3.67	35.6	1.21	0.47	35.47	62.8
Requirements	22.24		6.5	5.2	3.60	35.3	1.45			
Difference	0.04		0.4	0.1	0.08	0.3	-0.25			

Figure 4. Ration worksheet from Spartan Dairy 3. The ration worksheet contains ~120 columns of information, showing values for each feed and the total ration, and is organized in 12 tabs. The nutrient balance graph gives a quick view of supply relative to requirements for major nutrients. The animal being fed is briefly described at top of sheet. This ration is 31% NDF and 17% CP and meets requirements for most major nutrients within reason.

Evaluation criteria. We recommend the following goals for well-balanced diets (with values being % over or under requirement):

- DMI should be supplied within 2% (-2 to +2%) of predicted DMI unless animals are specifically being fed at restricted intake.
- At least two of the three fiber measures (NDF, ForNDF, EfNDF) should be above 0%.
- NEL target is between -10 and +5% for cows in early lactation. For dry cows and cows in late lactation, NEL should be -5 to +5%. For growing heifers, NEg should be -5 to +5%.
- For protein, either CP or MP should be >0% with the other >-10%. RDP should be >0%.
- All macrominerals should be between -5 and +10%, unless the excess is coming from non-mineral feeds, in which case the upper limit depends on toxicity or environmental issues specific to each mineral.
- If the concentration of trace minerals and vitamins within feeds are ignored, and the concentration in the diet is all coming from a supplement, then Se should be at -5 to +5% and all other trace minerals and vitamins be -50 to +50%.

Formulating a diet

Using the worksheet. Spartan 3 has several tabs of the ration worksheet (Figure 4). Most tabs are for a set of feed characteristics, such as fiber, protein, or cost. The first tab is the Home tab.

Most (but not all) of the information in the Home tab is duplicated from other tabs. The order of columns within the home tab can be rearranged by clicking on a heading and dragging it. A good order is: %diet, NDF, EfNDF, NEL, CP, RUP dig, FA, Ca, P, Se, CostDM, AsFed, and DM%. Feeds can be sorted several ways, often by clicking on the heading and releasing without moving. We recommend that feeds be sorted according to feed type and name, which can be done by clicking on the sort icon, the Feed Type heading of the Misc tab, or the Sort command of the menu.

Systematically formulating a diet. Once the animal has been described and the feeds have been added to the ration, the diet is ready to be formulated. Generally, diet formulation works best if feeds are added and amounts are adjusted on a DM basis or as a % of the diet on a DM basis. If the feeds are sorted according to feed type, then we will work down the list of feeds as we work down the nutrients in the nutrient balance graph. The criteria for defining a well-balanced diet are the same when formuating the diet as when evaluating a diet, as described earlier. We recommend the following steps:

1. Balance for fiber and energy by adjusting forages, byproduct feeds, and grains.
   a. If any supplements (mineral, vitamin, protein, or feed additives) are to be included at predetermined inclusion rates, add them first.
   b. If you want to use a byproduct feed, start with amounts that seem reasonable based on price, practical inclusion rates, and nutritional value. For example, we might consider starting the diet with 2 kg of cottonseeds and 2 kg of soyhulls.
   c. Add forages to make up about half the diet. If more than one forage is used, options are to set one first and adjust the other, or to make a mix of the two and adjust the mix. For high-producing cows, adjust forages until ForNDF is close to requirement; if the diet has a lot of high-fiber byproduct feeds, adjust until the EfNDF is close to requirement (ForNDF might still be short). For animals with low requirements, you may want to feed well above the ForNDF or EfNDF requirements.
   d. Add grains or other concentrate-type feeds until 98% of the predicted DMI is met (leave ~2% of the total DMI for mineral and vitamin supplements).
   e. If needed, adjust forages and grains so that fiber and energy supply seem reasonable based on the evaluation criteria listed earlier. These adjustments should be made by substituting in one for the other so that DMI stays unchanged, so for every 1 kg grain DM added, take out 1 kg forage DM. It may be impossible to meet both energy and fiber requirements–in such case, adequate fiber is the first priority. Being short on energy means the cow will mobilize body reserves, which is okay for a while.
   f. Adding fat may increase the energy supply, but be aware that the cow may eat less than predicted with added fats, especially oils. The Spartan DMI prediction does not account for this, so you should consider balancing for a lower DMI if you add high fat feeds.
2. Balance for protein by altering the concentrate portion of the ration.
   a. Add protein supplements, if needed, by susbstution for grain—so for every 1 kg of protein supplement added, take out 1 kg of grain. Balance for CP or Metabolizable Protein (MP).
   b. If the CP requirement is met, and more MP is desired, either add more of the protein sources already in the ration (and thus increase CP) or replace some of the current protein feeds with a high RUP protein supplement.

   c. Make sure RDP requirement is met and add more if needed.
   d. We seldom check lysine and methionine. If CP and MP supplies are adequate, and if the digested RUP is from a variety of protein sources, it is okay to be short by 10% on these amino acids.
   e. After balancing for protein, recheck the balance of fiber, energy, and protein.
3. Balance for minerals and vitamins—first for P, then Ca, then other macrominerals, and finally trace minerals and vitamins, paying special attention to Se.
   a. Remember that the mineral mixes in the Spartan feed library are examples, and the actual concentrations from available mineral packs must be entered into Spartan.
   b. If a complete mineral/vitamin supplement is used and if you are in a location with Se-deficient soils, add it to meet the Se requirement and then inspect everything else. Add any other minerals that might be needed.
   c. If balancing for DCAD (dietary cation anion difference), add any supplements to achieve target.
   d. If separate supplements are used, start with supplements that contain multiple minerals for vitamins. For example, a trace mineral supplement likely contains some macrominerals, and dicalcium phosphate supplies both P and Ca. Usually, salt is added at 0.25-0.5% of the diet and Na if often fed a little above requirements. For TM supplements, we often add the supplement to meet the Se requirement. Likewise, vitamin supplements might be added considering mostly vitamin E supply.
   e. As you use feeds from the Spartan library, note that we assign zero values to all trace minerals and vitamins for all feeds except the example mineral/vitamin supplements. Because of variation in feeds, we generally recommend adding enough trace mineral and vitamin supplements to meet 60 to 100% of the requirement for each trace mineral and vitamin. However, we recommend adding Se to 0.3 ppm.
   f. Go back and check everything one last time.
4. **Printing.** To print a ration of library, only one file can be open. To PRINT a short version of the ration, use Summary Report. Add in names if you want. Then hit the Print button on the right side and preview the diet. If everything looks okay, print a paper copy or a PDF file.
5. **Computer vs cow.** As with any computer program, the cow should be the judge of nutritional adequacy. Evaluate the actual response to a diet change by monitoring DMI, estimated energy intake, and milk production and then fine tune the diet accordingly. Body condition is helpful too but takes longer to evaluate. The DM content of wet feeds should be checked regularly.
6. The **Help Manual.** Please see the on-line help manual, which can be accessed by choosing Help from the menu.

APPLICATION FOR BRAZILIAN DAIRY CATTLE

In developing Spartan 3, we tried to make the program easily adaptable to different conditions. Most dairy nutrition models, including US Dairy NRC and Spartan 3, were developed mostly using cows in a temperate environment and mostly with feeds grown under temperate conditions. Brazilian forages are typically less digestible than those in the US, especially the northern US. In Spartan 3, the digestibility of feed fractions can be easily altered, and heat stress or grazing work requirements can be altered easily. More importantly, Spartan 3 was developed recognizing the limits of our current models and trying to minimize time spent on ration characteristics for which equations are not accurate. A small library of feeds typical for Brazilian conditions is available on the Spartan website, www.spartandairy.msu.edu..

One first apparent difficulty when applying a North American model to Brazilian conditions is the breed of cattle. There is no Girolando option in the breed options. However, the most important characteristics of a breed that will be used to formulate the diet are its mature and current body weight. Holstein and Gir crosses (Girolando) are usually smaller than North American Holstein cows (usually around 500 kg of live BW), and that can be easily altered at Spartan 3 by using the 'midsize breed' option, or simply by entering the desired mature body weight in the 'animal description' tab.

Other important difference is the energy value of Brazilian ground corn, which can be lower than North American corn. There is convincing evidence in the literature that Brazilian ground corn, probably because of being flint as opposed to dent, and with a more vitreous endosperm, has a lower NEL value. If that is the case, by reducing the NFC dig from 96 to 90% the NEL value of ground corn will be reduced by 7% for a high producing cow diet.

Sugarcane is a common forage used in Brazilian dairy herds, and it's not commonly used in North America. In the small library of Brazilian feeds found at www.spartandairy.msu.edu, we have included a typical ethanol variety of sugarcane than can be used when formulating a diet. One important aspect to consider when formulating diets with high sugarcane is that usually the feed intake will be lower than with corn silage based diets, likely because of the significant lower NDF digestibility of sugarcane. The Spartan3 model does not use ration characteristics, such as low NDF digestibility, to reduce predicted feed intake; therefore feed intake should be monitored on the farm. Also, because there is great variability in NDF digestibility among sugarcane varieties, it is important to have it analyzed at a university or commercial lab. Lignin should not be used to estimate NDF digestibility of sugarcane. The analyzed in vitro NDF digestibility can serve as a reference on how much to alter NDF digestibility in Spartan, but it may not accurately predict what will happen in the cow. Monitoring cow responses is key!