



Beef Cattle Library

Beef Cattle Sciences

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Balancing Diets for Beef Cattle ¹

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Introduction

Cattle nutrition is a critical component of beef operations. Within the OSU – Beef Cattle Library, there are several articles demonstrating the importance of adequate nutrition for growth, reproduction, and immunity of beef cattle. More than 60% of annual production costs in beef operations can be associated with cattle feeding, including forage production and feed purchase (Miller et al., 2001). Therefore, nutritional management of the herd needs to be properly designed to ensure optimum cattle performance while maintaining economical viability of the production system. There are several steps that producers and field personnel need to understand and follow when designing or evaluating cattle diets, including determination of animal requirements, assessment of feed inventory, and calculations to determine the type and amount of feeds that animals have to consume.

Cattle nutritional requirements

The first step in designing nutritional regimens for beef cattle is to determine the actual amount of nutrients that the animal needs to consume daily. Basically, cattle have daily requirements for water, energy, protein, minerals, and vitamins. These requirements change according to several factors, including age of the animal, stage of production, environment, and expected performance level. For specific information about

nutrients and nutritional requirements of beef cattle, consult BEEF003. It is extremely important to understand and feed cattle according to their specific requirements. Feeding less than what is needed will result in loss of performance, production efficiency, and may compromise animal health and well-being. Similarly, feeding in excess of an animal's requirements will not only negatively affect the economics of the operation, but will also be a detriment to production traits as overconditioned animals are less efficient in terms of feed utilization and have impaired reproduction (NRC, 1996; Cooke et al., 2009).

Feed inventory

There are several types of feeds available for cattle nutrition. These include forages and concentrate feeds. Forages are often the cheapest source of nutrients for cattle, and the major feed source for cow-calf and stocker operations in Oregon. However, many forages do not have the nutritional content needed to meet cattle requirements, particularly among growing and lactating animals. Even when the selected forage has adequate nutritional quality, but is not available in adequate quantities (see cattle intake requirements in BEEF003), cattle nutritional requirements will not be met. In these instances, supplemental nutrients are required and are often fed in the form of concentrate feeds, which can be rich in energy (such as corn and beet pulp), protein (soybean meal), or both (distillers grain and camelina meal).

1. This document is part of the Oregon State University – Beef Cattle Library. Published in June 2011. Prior to acceptance, this document was anonymously reviewed by two experts in the area. For further information, please visit the Beef Cattle Sciences website at <http://beefcattle.ans.oregonstate.edu>.
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Commercial supplements containing minerals and vitamin mixes, as well as protein and/or energy ingredients, are also widely available for purchase.

The second step in designing nutritional regimens for beef cattle is to determine if feed sources are available in adequate amounts and also contain the nutrient composition to meet cattle requirements. Given that forage is the main feed source for cattle in Oregon, cattle producers first need to ensure that their forage inventory (during grazing or upon harvesting) is sufficient for the feeding period, and then determine forage nutritional quality and compare that with cattle requirements. The OSU – Beef Extension Forage Evaluation program provides this service by receiving forage samples and providing producers with a recommendation report (<http://beefcattle.ans.oregonstate.edu/html/forage/Forage.htm>). Commercial laboratories can also provide this service, in addition to nutritional analysis of concentrate feeds.

Evaluating and balancing beef cattle diets

When cattle requirements and nutritional content of feeds are known, cattle performance can be predicted and producers can manipulate diet composition to control input costs by feeding cattle according to specific requirements. Therefore, the third step in designing nutritional regimens for beef cattle is to evaluate and/or balance the diets offered to cattle. This can be accomplished via simple mathematical calculations or computer programs, depending on the preference and skills of the user.

Mathematical calculations

The most common mathematical procedures for diet balancing are algebraic and Pearson Square methods. Both can be easily performed using a pencil, piece of paper, and a calculator. For the examples below, we will use a developing Angus heifer that weighs 500 lbs and needs to gain 1.5 lbs daily. All requirements and calculations will be performed on a dry matter basis (see BEEF003 to understand the concept and how to transform to as-fed basis). Based on her requirements, this heifer needs to consume 12.1 lbs of a diet that contains 10.3% of crude protein (CP) and 68.5% of total digestible nutrients (TDN; a measure of energy). The feeds available for this heifer are described in Table 1. It is clear that the forage in question (meadow hay) does not have the energy and protein content to meet the heifer's requirements; therefore,

supplementation with concentrate feeds will be required. Let's do the math.

Algebraic. This is a fairly simple method that can be used to determine the proportion of different feeds that results in a diet with the desired nutrition concentrations. Only two feedstuffs can be used in each calculation, but by repeating the process, more ingredients can be included into the final diet. Based on the scenario listed above, we will balance the diet beginning with TDN and then CP. It is always necessary to start with the nutrient required in the greatest amount, in our case TDN, and use a supplemental feed that is richer in TDN than the amount required. Therefore, how many lbs of hay and ground barley must be mixed to make 12.1 lbs of a diet that contains 68.5% of TDN? Based on the following formula, information from Table 1, and calculations:

- Let **a** = amount of hay needed, consequently the amount of barley need will be **12.1 – a**
- (hay TDN% × lbs of hay) + (barley TDN% × lbs of barley) = desired diet TDN% × lbs of total diet
- $(0.50a) + (0.75 \times (12.1 - a)) = 0.685 \times 12.1$
- $0.50a + 9.075 - 0.75a = 8.2885$
- $-0.25a = -0.7865$
- $a = 3.146$
- Therefore, a diet containing 3.146 lbs of hay and 8.954 lbs of ground barley will total 12.1 lbs of dry matter with 68.5% being TDN.

Table 1. Feedstuffs available for cattle consumption.

Feedstuff	Dry Matter (%)	TDN (%)	CP (%)
Meadow hay	92	50	6
Ground barley	88	75	11
Cottonseed meal	90	65	41

Now we need to determine how much CP the hay/barley mixture is providing. Given that CP content of hay is 6% ($3.146 \text{ lbs} \times 0.06 = 0.189 \text{ lbs}$ of CP) and barley is 11% ($8.954 \text{ lbs} \times 0.11 = 0.985 \text{ lbs}$ of CP), 9.7% of the diet is comprised of CP (0.189 lbs from hay + 0.985 lbs from barley, divided by 12.1 lbs of total diet). Therefore, additional protein is required to meet the heifer's CP requirement (10.3%). To achieve this goal, the same calculations demonstrated above will be repeated. However, this time the hay and barley mixture will be considered as a single feed, and we will determine how much of

cottonseed meal will be required to reach the goal of 10.3% CP in the diet.

- Let **a** = amount of cottonseed meal (CSM) needed, consequently the hay and barley mix = **12.1 – a**
- (CSM CP% × lbs of CSM) + (hay barley CP% × lbs of hay barley) = desired diet CP% × lbs of total diet
- $(0.41a) + (0.097 \times (12.1 - a)) = 0.103 \times 12.1$
- $0.41a + 1.1737 - 0.097a = 1.2463$
- $0.313a = 0.0726$
- **a** = 0.232
- Therefore, a diet containing 0.232 lbs of cottonseed meal and 11.868 of the hay/barley mix will total 12.1 lbs of dry matter with 10.3% being CP.

To determine the individual amounts of hay and barley in the diet, we will need to assess the proportion of each ingredient in the first mixture that we calculated (3.146 lbs of hay and 8.954 lbs of barley in 12.1 lbs of total diet = 26 and 74%, respectively), and multiply those numbers in the final mixture (26% of hay and 74% of barley in 11.868 lbs of the hay and barley mix). The amounts of each feed and the nutritional composition of this final diet is reported in Table 2.

The advantage of this calculation is that the nutritional composition of the diet can be assessed as % of total intake, or in actual measures of intake (lbs), whereas cattle requirements are described in both ways (see BEEF003). Clearly, it is difficult to mix an individual diet with the precision (three decimal numbers) described in Table 2. However this precision is necessary when mixing a large batch of the concentrate supplement (barley and cottonseed meal) to facilitate feeding and uniformity of the diet, such as 5,000 lbs that will last 11 days if 50 heifers are being fed, the mixture will require 4,871 lbs of ground barley and 129 lbs of cottonseed meal.

Pearson Square. This method is very similar and uses the same concepts as the algebraic method. The major difference is that Pearson Square calculations are based on proportions (% of each ingredient in total diet) rather than absolute values (lbs of ingredients). Specific information about Pearson Square can be found in Appendix 1 within this publication, with a practical example utilizing the same scenario described above.

Table 2. Nutritional content of the diet balanced for replacement heifers.

Feedstuff	Amount (lbs)	TDN (lbs)	CP (lbs)
Meadow hay	3.086	1.543	0.185
Ground barley	8.782	6.587	0.966
Cottonseed meal	0.232	0.151	0.095
Total diet	12.1	8.28	1.246
<i>Dietary inclusion rate</i>		<i>(68.5% of diet)</i>	<i>(10.3% of diet)</i>

Computer Programs

There are several computer programs designed for diet evaluation and balancing. They vary from simple spreadsheets with calculations similar as those described above, to complex systems that involve several intrinsic parameters such as ruminal fermentation, microbial synthesis, etc. The advantages of these programs are the amount of information they can process in a short period of time, and the fact that they contain large databases with information related to cattle requirements, nutritional content of feeds, economical variables, etc. Examples are:

- **TAURUS:** Developed by the University of California, Davis. It can be purchased for \$400 at (530) 752-1278 or at <http://animalscience.ucdavis.edu/extension/Software/Taurus>.
- **BRANDS:** Developed by the Iowa Beef Center at Iowa State University. It can be purchased for \$475 at [http://www.iowabeefcenter.org/software BRANDS.html](http://www.iowabeefcenter.org/software_BRANDS.html).
- **SPARTAN 3:** Developed by Michigan State University. It can be purchased for \$450 at <http://spartandairy.msu.edu/>. The previous version (SPARTAN 2) can be downloaded for free at <https://www.msu.edu/~ssl/index.htm>.
- **OSU CowCulator:** A producer-friendly software developed by Oklahoma State, adapted for Oregon. It can be downloaded for free at the Oregon State University – Beef Cattle Sciences website at <http://beefcattle.ans.oregonstate.edu/html/forage/Forage.htm>. Questions about the CowCulator can be addressed to the authors of the present article.
- **NRC:** Developed by the National Research Council. It can be downloaded for free at <http://www.nap.edu/html/beefmodel/>.

- **Cornell Net Carbohydrate and Protein System:** Developed by Cornell University. It can be downloaded for free at <http://www.cncps.cornell.edu/downloads.html>.

NRC. 1996. Nutrient Requirements of Beef Cattle. National Academy Press, Washington, D.C.

These programs vary in complexity, and the latter two require significant expertise and training in cattle nutrition. For questions about these software programs, each has instructions available for download.

Conclusion

Nutritional management is an imperative component of beef production systems; therefore cattle should receive diets that meet their requirements to ensure optimum performance and profitability. The first step to achieve this goal is to determine the animal's requirements for basic nutrients, including energy and protein. The second step is to evaluate the feed inventory and determine if supplemental feeds are required. The third step is to evaluate and balance diets according to cattle requirements and available feeds. The techniques described herein are only tools to help the producer in the nutritional management of the herd, and should not be used as the main and only source of information. Cattle performance will depend on the quality and viability of the resultant diet, the accuracy of information used in the calculations (i.e. cattle requirements and nutritional profile of feeds), and the experience and practical knowledge of the user. In some cases, the calculations or computer programs may suggest a diet consisting of feedstuffs that mathematically meet the requirements of the evaluated animal but will be extremely detrimental to animal health and well being. Therefore, the tools reported herein should be used in conjunction with basic concepts of cattle nutrition and field observations of cattle performance and health to ensure that the nutritional status of the herd is adequate.

References

- Cooke et al. 2009. J. Anim. Sci. 87:4125-4132.
- Filley, S. J. 2009. OSU – Beef Cattle Library, BEEF003.
- Miller et al. 2001. Prof. Anim. Sci. 17:295-302.