The Transition Dairy Cow

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By

Pedro Melendez

With contributions by Sha Tao, Julian Bartolome, Pablo Pinedo and Qiang Dong

Cambridge Scholars Publishing

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PREFACE

This book is the culmination of a process of intellectual, professional, and academic development that began with my veterinary medicine degree in 1990 in Chile. However, fulfilling my residency program in dairy production medicine and completing my MS and PhD, both finalized at the University of Florida, were instrumental in achieving the experiences that allowed me to write and edit this book.

There were many friends, teachers, and mentors who left an invaluable footprint on my academic, professional, and personal development. Therefore, I cannot fail to mention and thank my friends Julian Bartolome, a classmate from graduate school, and others like Dr. Victor Monterroso, Antonio Landaeta, Gina DeChant, and Martin Giangreco. On the mentor's and professors' side, my most sincere gratitude goes to Dr. Louis Archbald (graduate coordinator of the Department of Large Animals Clinical Sciences), who believed in me at a delicate time when my acceptance to the graduate program was pending due to my precarious English level.

He gave me the opportunity, and I only had to repay him by being an exemplary student, achieving a 4.0 GPA throughout my MS and PhD program, and attaining the Alec Courtelis award as the best international graduate student from the University of Florida in 2004.

Very humbly, these acknowledgments go to Dr. Archbald and the rest of my committee, including Dr. Carlos Risco (my friend) and Dr. Art Donovan (my committee chairman), as a form of gratitude for never losing their faith in me.

I make special mention of Dr. Ramon Littell (Professor of Statistics and leader in the development of mixed models for repeated measures) and Dr. Art Donovan, who gave me the tools to understand better and appreciate statistics and epidemiology, as well as the concept of population health and herd medicine throughout my academic training program. By the same token, I also appreciate the support and mentoring of Dr. Ken Braun, Dr. Owen Rae, Jan Shearer, and Jorge Hernandez. Furthermore, from the Department of Dairy and Animal Sciences, I wish to extend my deepest appreciation for the mentoring of both Dr. William (Bill) Thatcher and Peter

Hansen. Finally, my most sincere acknowledgment goes to Dr. Jesse Goff (external member of my committee and perhaps the veterinarian with the greatest knowledge on mineral metabolism and metabolic diseases in transition dairy cows), who has been fundamental to this day in my academic and professional progress. I am incredibly thankful for the priceless friendship that we have developed over the years.

Special mention also goes to all the friends and colleagues I have met since graduate school (Scott Poock, Matt Lucy, Mike Van Amburgh, Daryl Nydam, Delores Foreman, Don Bennink, Maria Paz Marin, Mario Duchens, Tom Jenkins, David Weber, Surya, Omid, Manuel, Brett, Hemant, Roberto, Marcelo, Prasanth, Sha, Pablo) and many others that I may have forgotten. However, all this would not have been possible without the unrestricted support of my wife, Maria Ester, and my children, Ignacio, Diego, and Elisa, who always inspired me to continue growing professionally. Until today, I always taught them the importance of education in life. To my wife, I am indubitably indebted. The sacrifices she has made to grant me her constant and unconditional support are forever on my mind. She is the perfect wife and mother one could ever hope for. Without a doubt, all this is sustained by the values that my parents and my brother gave me during my childhood. To my mother, Eliana, may she rest in peace; to my father, Oscar, who is not with us anymore; and to my brother, Oscar, and grandmother, Luz Maria, for guiding me during my upbringing.

CHAPTER 1

INTRODUCING THE TRANSITION DAIRY COW

The production cycle of a dairy cow, whether in confinement or under grazing management is based on a logical sequence that must be conceived as a whole, in a holistic sense (Figure 1).

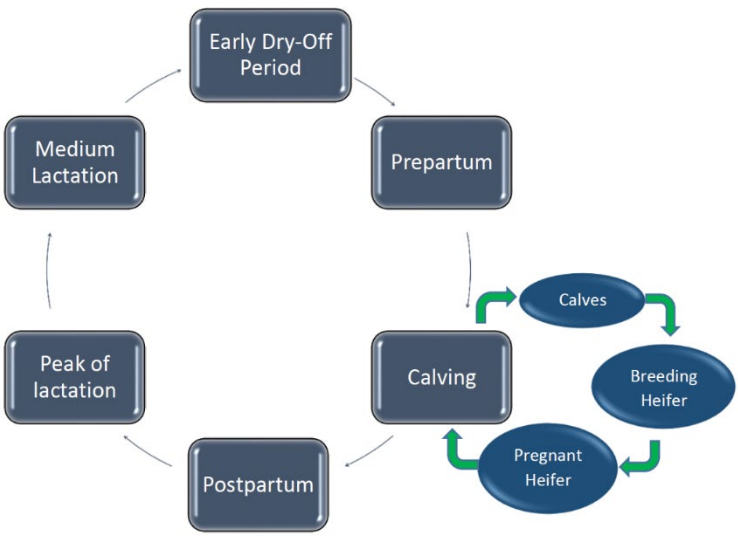

Figure 1. Production Cycle of a Dairy Cow.

All stages of this cycle are important; however, some phases are more critical than others, which determines the success of the production system. Within these, the calving process is the most stressful and critical time of the entire production cycle because the health of the cow, the fertility, and the lactation progression depend on a successful parturition outcome. Frequently, the rearing of the calf and the replacement heifer are considered sub-systems that may or may not be carried out under conditions of complete housing, depending on the available facilities and/or the available land area of the farm. Therefore, the success of the production system is understood in the context of achieving a viable calf and a healthy cow that can fully express their genetic potential.

Within the entire production cycle of dairy cows, the transition period comprises the last 3 weeks of gestation and the first 3 weeks of lactation, including parturition. The transition period is characterized by several metabolic, endocrine, immune, and digestive adjustments that the cows must experience to achieve adequate lactational and health performance. One of the major challenges for the transition cow is the reduction in dry matter intake (DMI) during the last weeks of gestation, followed by a slow increase in feed consumption during the postpartum period, with a nadir around parturition. This DMI reduction is explained by the exponential growth of the fetus in the pregnant cow that reduce the space in the abdominal cavity, and by the metabolic and hormonal signals that induce biological responses at the central level of the nervous system. Furthermore, energy requirements for lactogenesis increase abruptly right after parturition. As a result, the cow develops a typical postpartum negative energy balance (NEB), which is characterized by hypoglycemia since glucose is used for the synthesis of lactose during lactogenesis. These metabolic responses are the result of the increased synthesis and release of IGF-I and growth hormone, the reduction in the synthesis and release of insulin, and the surge of catecholamines which in turn activate the hormone-sensitive lipase system and other enzymes in the adipose tissue, triggering the typical breakdown of ester bonds of triglycerides (TG), releasing glycerol and non-esterified fatty acids (NEFA) into the bloodstream. This physiological mechanism may turn into a vicious cycle in which several key compounds are restricted, reducing the available precursors for gluconeogenesis. As a result, major metabolic pathways are shifted, with the typical adaptative nutrient partitioning characterizing transition dairy cows. In this intricate scenario, the liver is considered a pivotal organ participating in the regulation of the entire metabolism, where, particularly in high-producing dairy cows, it may surpass its normal function, leading to a series of local and/or systemic inflammatory and/or degenerative processes compromising the integral animal health. Consequently, the cow becomes more susceptible to developing secondary diseases including ketosis, displaced abomasum, mastitis, retained fetal membranes, metritis, reduced fertility, and low milk production.

On the other hand, during the prepartum period, the cow must be prepared for the onset of lactation, particularly for maintaining calcium and magnesium homeostasis. Furthermore, during the prepartum period, the adaptation of the rumen to high starch-containing diets fed during the postpartum period must be implemented. Finally, since a critical point of immunosuppression occurs around parturition, a well-balanced diet to reduce the oxidative stress and meet all the requirements of the cow, and maintenance of adequate cow comfort to prevent environmental stress must be strategically provided.

If the physiological changes experienced during the transition period are not well managed, they may lead to the development of metabolic disorders that worsen immunosuppression, resulting in a higher incidence of infectious diseases and proinflammatory disorders. Moreover, metabolic demands in early lactation increase the production of reactive oxygen species (ROS), leading to oxidative stress, while metabolites, including saturated FA, as well as damage-associated molecular patterns, such as cytokine production, can trigger inflammatory responses.

The harmful impact of a pronounced NEB may extend beyond the transition period, negatively affecting the body condition score (BCS) dynamics after parturition which becomes a powerful risk factor to reduce well-being and fertility and increase the culling risk throughout the entire lactation. This process may generate a chain of events in which the NEB upregulates or downregulates key enzymes, reducing further the levels of essential metabolites, and limiting the precursors available for glucose synthesis.

Calcium and magnesium homeostasis is an additional challenge that the dairy cow must face during the transition period. Twenty-four to 48 hours before parturition Ca starts to be drained in great amounts to the mammary gland for colostrum synthesis.

There are multifactorial interactions between nutrition and immunity that must be understood to establish more effective management strategies to prevent and control health conditions during the peripartum period. Nutrients are crucial for milk production and for an efficient response of the immune system. Therefore, major strategies for transition dairy cows must be addressed to minimize the stress as much as possible considering the most fundamental approach an optimal cow comfort and proper calving management. Moreover, other environmental stressors, such as suboptimal nutrition, or summer parturitions under heat stress, most likely will negatively impact the normal physiological responses of transition dairy cows. The carry-over effect of these postpartum disorders will extend beyond this period and will compromise subsequent conception and embryo survival, impairing the overall fertility of the herd.

In the end, the transition period becomes the most complex and challenging time for the dairy cow that must face during her entire productive cycle. In this scenario, the goals for a proper transition period management are to provide adequate cow comfort, avoid an extreme NEB, reduce the severity of hypocalcemia, decrease the oxidative stress, modulate the negative protein, mineral, and vitamin balances, adapt the rumen to higher starch density diets and moderate to its minimum expression the typical immunosuppression occurring in this period.

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CHAPTER 2

NUTRITION MONITORING TOOLS FOR TRANSITION DAIRY COWS

The nutritional management of dairy cows should be focused on meeting the requirements of all essential nutrients throughout the cow's productive cycle. As the cow undergoes the various physiological processes of her cycle (such as the last third of lactation, dry period, parturition, early postpartum, peak lactation, etc.), the requirements for each essential nutrient (energy, fiber, protein, minerals, vitamins, and water) vary according to each stage of the cycle. In certain circumstances, physiological stages overlap, for example, lactation and pregnancy, and therefore the requirements need to be integrated. Additionally, under adverse environmental conditions (such as rain, mud, excess heat and humidity, and low temperatures) and suboptimal animal welfare conditions, maintenance requirements increase. Hence, these aspects must be considered when establishing a nutritional and feeding management program. Undoubtedly, conditions of environmental stress and inadequate animal welfare will escalate feeding costs or result in lower cow productivity, leading to reduced profitability of the system.

In any productive system and type of feeding management, it is necessary to fully understand the feed nutritional composition that is going to be used in the feeding program of the herd. For this purpose, the chemical and nutritional analysis of feedstuffs is essential to reach the established productive goals.

Characterization of feedstuffs

The chemical and nutritional analysis of ingredients to be used in a diet is crucial for effective feeding management throughout the production cycle of dairy cows. There are two types of nutritional analysis: wet chemistry and near-infrared spectrophotometry (NIRS). NIRS is a faster and more cost-effective method, but it relies on standard curves and proper equipment calibration, which can affect its precision. On the other hand, wet chemistry offers greater precision and accuracy, but it requires more time and is more expensive.

In general, feed with higher content of moisture presents a greater variability in the result of their nutritional composition, therefore random and representative sampling is essential to obtain a precise result. In this sense, the order of importance in the variability of the results of a nutritional analysis is firstly fresh forages, silages, agroindustry byproducts with high moisture content, hay, and straw, and finally concentrates. For a better understanding of how to obtain representative samples of silage, total mixed rations (TMR), and hay, the following websites are recommended:

Total mixed ration: http://www.rockriverlab.com/Section/Feed/Sampling_Techniques/index.html

Silage: https://www.youtube.com/watch?v=VabSZnKoqho

Hay and straws: https://www.youtube.com/watch?v=MVfWWaTdB9o

Understanding nutritional analyses

Nutritional analysis is an important component of well-managed feeding programs in dairy herds. Several laboratories are conducting both wet chemistry and NIRS. The most common nutritional fractions determined in these analyses are:

Moisture – It is the % of water contained in a feed sample.

Dry Matter – It is equal to 100%. It is the sum of all the nutrients present in the sample. All interpretations of nutritional fractions must be interpreted on a *DRY MATTER* basis since this is what ultimately contains the nutrients that the cow consumes. The water content of the sample does not matter. It is extremely important to know the dry matter content of feeds to ensure that the cows receive the appropriate amount of nutrients to meet their nutritional requirements.

As Fed basis – means that the nutrients in a sample are being expressed in their natural state, including water.

Dry Matter (DM) Basis – the nutrients in the sample are expressed with water removed from the calculation. This is very important to keep in mind since there is considerable variation in the moisture content of forages. When the nutritional values of forages or any feed are to be compared, they must be based on their DM matter content.

Crude Protein (CP) – this is the total protein content of the sample which is nothing more than the total nitrogen content of the sample multiplied by 6.25. It therefore reflects both true protein and non-protein nitrogen, but it says nothing about the quality of the protein.

Urea and Ammonium – These chemical compounds contain nitrogen but are not true proteins. However, in the cow's rumen, this non-protein nitrogen can be utilized by rumen microorganisms for their multiplication and converted into microbial protein. Urea and ammonium are part of the protein fraction known as "soluble protein."

Soluble Protein (SP) – are proteins and non-protein nitrogen that are rapidly (minutes) degraded and/or dissolved in the rumen and used by rumen bacteria.

Rumen Degradable Protein (RDP) – consists of all soluble proteins and other proteins that have an intermediate degree of degradability (slower than soluble) at the ruminal level and is also used by bacteria for their multiplication.

Rumen Non-Degradable Protein (RNDP) – are proteins that have a very slow degradation rate and therefore escape the digestion of rumen microorganisms and pass intact to the abomasum. It is also known as a bypass protein. This non-degradable protein is digested in the abomasum and duodenum and absorbed as amino acids at the intestinal level.

Acid Detergent Insoluble Crude Protein (ADICP) – also known as unavailable or heat-damaged protein. This type of fraction typically originates in the drying processes of some feedstuffs where the protein portion reacts with carbohydrates to form an insoluble and indigestible complex that is unavailable to the animal.

Neutral Detergent Insoluble Crude Protein (NDICP) – Represents all insoluble, non-degradable, and unavailable protein for the animal.

Neutral Detergent Fiber (NDF) – is a measurement of hemicellulose, cellulose, and lignin representing the entire fibrous part of the feed. These 3 compounds form part of the cell walls of forages and are generally called "structural carbohydrates". The NDF content of diets or forages is negatively correlated with DM intake. Then, excess NDF will reduce feed intake in the cow.

NDFom – This measurement is based on measuring NDF, but free of ash or minerals, consequently the result is based only on organic matter (om). When the sample is treated with amylases to digest any starch contamination of the NDF, then a final pure fraction free of ashes and starch is obtained (aNDFom).

Acid Detergent Fiber (ADF) – is the quantification of cellulose and lignin. As the lignin content increases, the digestibility of cellulose decreases; Therefore, the ADF content is negatively correlated with the total digestibility of the evaluated forage.

Lignin – is an indigestible component of forages. It is composed of polymers made by cross-linking phenolic compounds. The more mature a plant is, the higher its lignin content is, and therefore the less digestible the forage is.

Crude Fiber (CF) – is an old method that quantifies fiber and was used to classify carbohydrates into digestible and indigestible. Crude fiber contains almost all the cellulose content and only a portion of lignin. Therefore, it is a method that should be left aside since it does not provide an accurate assessment of the structural carbohydrates in forages. Yet, many laboratories and nutritionists continue using this method as a nutritional indicator of fiber.

In Vitro True Digestibility (IVTD) – is an anaerobic fermentation carried out in the laboratory to simulate the digestion that occurs in the rumen. For this purpose, ruminal fluid from cannulated cows is used and the samples are incubated for a defined period at 39ºC (cow's body temperature).

Neutral Detergent Fiber Digestibility (NDFD) – is the % of potentially digestible NDF and is determined by incubation with rumen fluid and is used to rank forages on the potential digestibility of their fiber and to calculate values of energy of forage samples.

Pectin – is a compound of cell walls that functions as a cell binder. It is also known as Soluble Fiber. It presents a faster degradation than normal fiber components (cellulose, hemicellulose) and despite being part of the NDF, its degradation characteristics are more like non-structural carbohydrates, such as starch, but with the exception that they do not cause rumen acidosis.

Starch – is a glucose-rich polysaccharide found mainly in cereal grains, seeds, and/or plant roots. They are part of the fraction known as non-fibrous carbohydrates.

Water Soluble Carbohydrates (WSC) – Includes simple sugars and some more complex ones such as fructans, which are part of the grass sugars.

Non-Fibrous Carbohydrates (NFC) – These are carbohydrates that do not belong to the cell wall or fiber fraction. Starch, simple or soluble sugars, organic acids, and in some cases, pectins are part of this fraction. They are calculated by the formula NFC= 100% - [CP% + (NDF% - NDICP%) + Fat% + Ash%].

Crude Fat or Ether Extract (EE) – typically determined by "ether" extraction. Fats are highly energy-dense nutrients and contain 2.25 to 2.8 times the amount of energy found in carbohydrates.

Total Fatty Acids (TFA) – is a type of fat that is extracted with methanol and hexane and measured by gas chromatography. They are part of the TG contained in the EE.

Energy - Energy is a fundamental nutrient for life but its chemical evaluation is conceptual. Therefore, the energy values of feedstuffs are obtained by predictive equations or formulas using other nutrients that can be measured chemically (carbohydrates, protein, fats). The energy value of a feed for dairy cows is different from the energy value of the same feed for pigs. This is because feed is utilized with different efficiency between these 2 species.

Total Digestible Nutrients (TDN) – is the sum of protein, non-structural carbohydrates, NDF, and 2.25 times the fat content or EE.

Gross Energy – is the total energy value of a feed before it is consumed by the animals. That is, it is all the heat released by this feed if it were completely combusted.

Digestible Energy (DE) – is the gross energy minus the energy lost through feces.

Metabolizable Energy (ME) – is the gross energy minus the energy lost in feces, urine, and gases.

Net Energy for Lactation (ENL) – is an estimate of the feed energy useful to maintain the animal and to produce milk during lactation and for pregnant and dry cows until calving.

Ash – is a measurement of the total mineral content of the sample.

Some laboratories can measure all minerals and others only some of them. Among the minerals to be measured are the macrominerals: Calcium (Ca), Phosphorus (P), Magnesium (Mg), Potassium (K), Sodium (Na), Sulfur (S), Chlorine (Cl); and the microminerals: Iron (Fe), Zinc (Zn), Copper (Cu), Cobalt (Co), Selenium (Se), Molybdenum (Mo), Manganese (Mn) and Iodine (I).

Relative Feed Value (RFV) – is an index that classifies forages based on their digestibility and potential intake. It is calculated from the NDF and ADF content. An RFV value of 100 is considered a standard value based on alfalfa hay containing 41% ADF and 53% NDF on a DM basis. The higher the RFV, the better the quality of the feed.

Relative Forage Quality (RFQ) – is an index for ranking forages based on a more comprehensive analysis than RFV. It is calculated from the CP, ADF, NDF, fats, ashes, and digestibility of the NDF up to 48 hours. The base score is also 100 and the higher the RFQ, the better quality that forage has.

Nitrates (NO_3) – is a compound that can be toxic to animals. Certain plants tend to accumulate nitrates and therefore it is sometimes important to evaluate this compound. Some accumulating plants are sorghum, sweet grass, and oats.

pH – is a measurement of the degree of acidity of a feed, especially silages. Good corn silage should have a typical pH between 3.5 to 4.5 and alfalfa haylage or silage between 3.8 to 5.3.

Volatile Fatty Acids (VFA) – primarily, acetic, propionic, and butyric acids produced by a microbial fermentation process in both silages and the rumen of a cow. Although lactic acid is non-volatile, it is included in this evaluation as total acids.

Figure 2.1. Nutritional analysis report for a sample of corn silage using the CNCPS platform.

ROCK RIVER LABORATORY, INC. AGRICULTURAL ANALYSIS

Received: 2/15/2022 **Sampled:** 2/14/2022
Rep: Pedro Melendez John Borzillo
/ Corn Silage

Moisture: 69.78
Dry Matter: 30.22

Protein & Amino Acid	**%DM**	**60d**	**4 yr**
Crude Protein	8.26	7.24	7.51
Total Amino Acid	8.05	6.88	6.97
Sol. CP, % of CP	58.43	56.54	53.32
NH3-N CP Equivalent	0.68	0.67	0.39
NH3-N, % of CP	8.23	9.26	5.32
ADICP	0.60	0.65	0.64
NDICP	1.26	0.94	1.03
ADICP, % of CP	7.24	9.06	8.50
Available CP	7.66	6.58	6.87
Nitrate-N, ppm			
Non-Protein Nitrogen			
Calculated Amino Acids			
Lysine, % of CP	3.11	3.08	3.04
Methionine, % of CP	1.96	1.94	1.92
Histidine, % of CP	2.29	2.27	2.24
Minerals & Ash			
Ash	7.47	5.20	4.27
Calcium	0.27	0.20	0.16
Phosphorus	0.19	0.22	0.22
Magnesium	0.19	0.15	0.13
Potassium	1.10	1.00	0.94
Sodium			
Sulfur	0.12	0.09	0.08
Chloride			
Aluminum			
Boron			
Copper			
Iron			
Manganese			
Molybdenum			
Zinc			

Carbohydrates	**%DM**	**60d**	**4 yr**
ADF	30.50	22.33	22.31
aNDF	48.59	38.50	38.59
aNDFom	46.21	36.80	37.15
Lignin	5.60	3.95	4.06
Starch	20.84	34.32	34.72
Sugar (ESC)	2.07	1.68	1.66
Sugar (WSC)	2.80	4.09	4.32
Glucose			
Fructose			
Sucrose			
Lactose			
Mannitol			
Total Sugar			
Crude Fiber			
Fermentation Products			
pH	3.88	3.87	3.96
Lactic Acid	4.71	4.48	3.61
Acetic Acid	2.68	2.17	1.53
Butyric Acid	0.00	0.00	0.00
Propionic Acid			
Succinic			
Formic			
Total Acids			
Ethanol			
1,2 Propanediol			
1 Propanol			
2,3 Butanediol			
2 Butanol			
2 Propanol			
Fermentation DM Loss	3.56	1.85	2.14
Ethyl Lactate			
Ethyl Acetate			

Fat	**%DM**	**60d**	**4 yr**
Ether Extract	2.56	2.65	2.58
Total Fatty Acid	1.59	1.82	1.78
Acid Hydrolysis			
	% of FA		
Myristic (C14:0)	0.84	0.41	0.41
Palmitic (C16:0)	18.23	16.75	15.12
Stearic (C18:0)	2.39	1.96	1.90
Oleic (C18:1 c9)	17.95	20.83	20.91
Linoleic (C18:2 c9,12)	41.98	47.68	47.60
Linolenic (C18:3 c9,12,15)	8.91	7.76	6.43
RUFAL	68.84	76.27	74.93
Nutrient Digestion, % of nutrient			
tNDFD12	17.37	21.74	20.67
tNDFD30	56.87	60.04	58.20
tNDFD48	64.72	67.49	67.23
tNDFD72			
tNDFD120	66.33	71.31	70.72
tNDFD240	69.21	74.38	74.04
tNDFD30om	59.89	62.98	61.25
tNDFD120om	69.04	73.84	73.21
tNDFD240om	71.83	76.75	76.38
sNDFD24	26.13	27.62	23.16
sNDFD30	35.83	35.19	28.95
sNDFD48	48.97	49.28	47.52
uNDF30, % DM	20.96	15.29	16.05
uNDF240, % DM	14.96	9.84	9.97
isSD0	28.41	37.81	25.13
isSD3	67.20	76.81	68.14
isSD7	81.72	82.98	80.06
isSD16	95.82	95.25	91.47
isSD24	96.11		
in situ RUP 16h			
RUP intest. dig., % RUP			

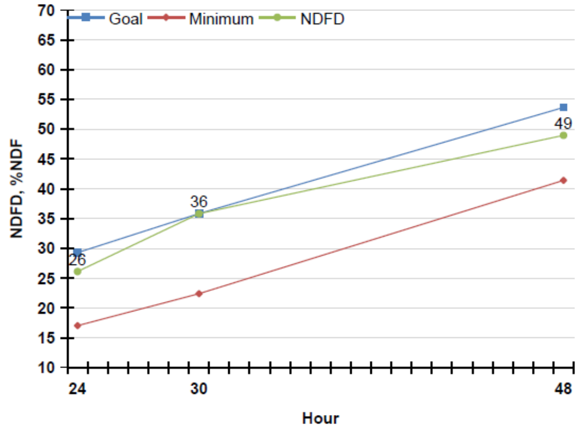
Comprehensive Nutrition Analysis Report

Calculations	**%DM**	**60d**	**4 yr**
Dynamic NDF kd, %/h	4.75	4.34	4.20
Dynamic Starch Kd, %/h	23.76	24.33	22.42
RFV			
RFQ			
TTNDFD, % of NDF	42.19	42.65	41.30
Total Tract Starch Dig			
NFC	34.38	47.33	48.00
DCAD			
Salt			
RDP %CP			

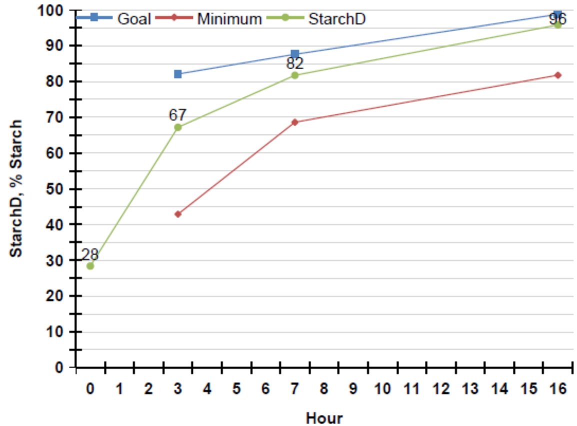
Energy Calculations	**TDN**	**NEL**	**NEG**	**NEM**
ADF (PA)				
OARDC Dairy				
NRC2001 Dairy				
Milk2006 Dairy	65.08	0.626	0.437	0.708
NRC2016 Beef				
Milk lb/Ton, Milk2006	2805			
Beef lb/Ton, NRC2016				

Anti-Nutrients
Mold (Guidelines)
Yeast (Guidelines)
DON, ppm
Aflatoxin, ppb
Zearalenone, ppb
Fumonisin, ppm
T-2, ppb
Ochratoxin-A, ppb
Clostridium perfringens
Enterobacteria

NDF Digestion Curve



Starch Digestion Curve



Body Condition Score

Body condition score (BCS) is the evaluation of the body fat reserves accumulated in the subcutaneous tissue of the cow. However, there is also stored fat in the abdominal cavity that has an important role in the general metabolism of the cow today it is not possible to measure it visually unlike the BCS. The correlation of abdominal fat with BCS is not 100% and therefore there may be 2 cows with the same BCS but with different abdominal fat content. This difference may have greater implications for the normal metabolic functioning of the cow. However, although the association between BCS and abdominal fat is not 100% full, in general, the higher the BCS, the greater the abdominal fat content. Therefore, the evaluation of the BCS continues to be a strategic tool for monitoring the energy nutrition of dairy cows. This is because BCS is a quick, cheap, and effective tool to evaluate the nutritional management of the herd. More importantly, the use of this tool between 2 periods of the cow's productive cycle indicates the dynamics of change in BCS which can be associated with a series of consequences. For example, it is expected the cow to slightly increase her BCS between mid-lactation (200 to 250 days in milk) to dry off. The cow should also maintain or slightly increase her BCS between dry-off and calving, and then decrease her BCS to a level that does not compromise the animal's health during the first month of lactation. Therefore, BCS should be strategically assessed at calving, at 30-45 days postpartum, at 200-250 days in milk, and at dry-off, and eventually at the beginning of the prepartum (30 days before expected parturition).

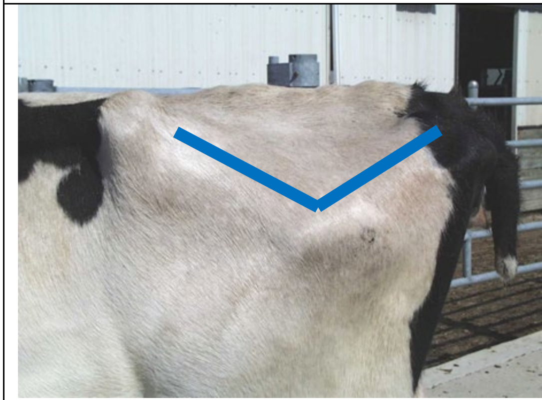
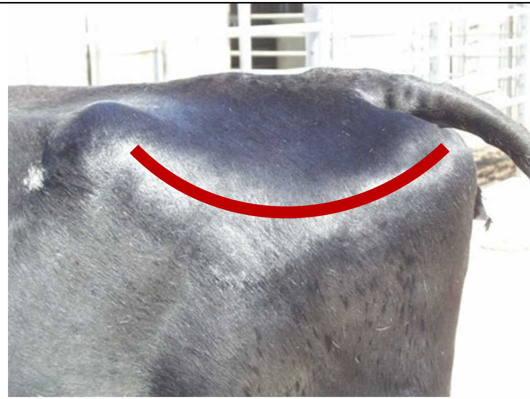
There are several BCS evaluation charts and the most used worldwide is the scale from 1 to 5 with 1/4-point increments, with score 1 being a completely emaciated cow and 5 a completely overweight fat cow. Changes in BCS beyond recommended values have been associated with several negative implications for cow health, production, and fertility.

The evaluation consists of the visual assessment of strategic external anatomical points of the cow. The first step is to observe the animal from either side. The area known as the rump, that is between the coxal bone (hip bone), and the ischial tuberosity (pin bone) should be evaluated. If a “V”-shaped depression is observed in this area, then the BCS is 3.0 or less. If the area has a less marked depression, with a “U” shape, then the BCS is 3.25 or more. This first measurement is the most critical because it will determine the cut-off point of the evaluation up or down.

After defining the cut-off, the animal must be evaluated from the back, observing mainly both coxal tuberosities and the area that covers the spine of the animal, considering the sacral ligaments. Both ischial tuberosities and the ligaments at the base of the tail should also be evaluated. In a cow with a “V” shape in her lateral evaluation on the rump area (BCS 3.0 or less), if the coxal tuberosities (hips) appear rounded and a slight depression is observed between the coxal tuberosities and the spine of the animal, then the cow is classified as BCS = 3.0, and further evaluation of the animal is not required. However, if the coxal bones are angular, then the BCS is 2.75 or less and it is required to proceed to the next step of the evaluation and assess the animal's ischium. If they are found to have obvious fat deposits and their extremes are rounded instead of angular, then the BCS is 2.75 and no further evaluation is required. On the contrary, if the ischium is angular and appears triangular, then the BCS is 2.5 or less. After this point, the ligaments of the tail should be evaluated. If they are not very visible and the depression at the base of the tail is not too marked, then the BCS is 2.5. If the ligaments are quite evident, and a clear depression is observed at the base of the tail, then the BCS is 2.25 or less and the transverse processes of the lumbar vertebrae should be evaluated. If these transverse processes are observed with a depression up to half their extension, then the BCS is 2.25. If the depression is up to 2/3 of the transverse process, then the BCS is 2.0. From this point it is difficult to classify the animal and the method becomes less consistent between different evaluators. However, animals with BCS of less than 2.0 are rare and if they represent a high proportion within a herd, it is urgently recommended to evaluate in deep the overall nutritional and feeding management of the dairy.

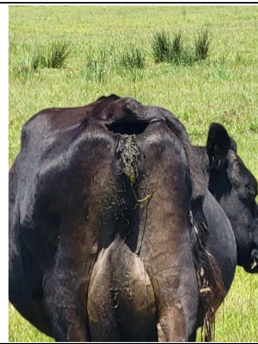
Now in a cow that presents a “U” shape in your lateral evaluation of the rump area (BCS 3.25 or more), the next step is to evaluate the cow from behind at the coxal bone. If they are slightly angular and the lateral area continues to be classified as “U” shaped, which can occur in some cases, then the animal should be classified with a BCS of 3.0. However, if the hips are rounded, and the tail and sacral ligaments or the depression between the hips and the spine are noticeable, then the BCS is 3.25, and no further evaluation is required. If the tail ligaments are barely visible, and the depression between the hips and the spine is slightly visible, then the BCS is 3.5 and no further evaluation is required. If the tail ligaments are no longer observed, and the depression between the hips and the spine is slightly visible, then the BCS is 3.75 and no further evaluation of the animal is required. If the depression between the hips and the spine is not visible, then the BCS is 4.0 or more and now the evaluation of the lateral side of the animal must follow. If the rump area is slightly depressed, then the BCS is

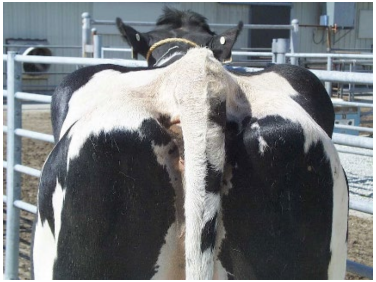
Figure 2.2. Lateral view evaluation for BCS (scale 1 to 5)

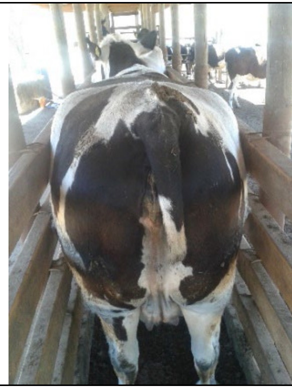
Lateral view: Area between hip and pin bones (rump)	
	
“V” shape view: BCS 3.0 or less	**“U” shape view: BCS 3.25 or more**

Source: Ferguson et al., 1994

Figure 2.3. Several BCS assessments based on Ferguson et al., 1994.

Further evaluation after the lateral view cut-off value assessment		
BCS 1.0	**BCS 2.0**	**BCS 2.25**
		
BCS 2.5	**BCS 2.75**	**BCS 3.0**
		

BCS 3.25	BCS 3.5	BCS 3.75
		

BCS 4.0	BCS 4.5	BCS 5.0
		

4.0 and no further evaluation is required. If the rump looks completely soaked in fat and flat, the BCS is 4.25 or more. If the lumbar transverse processes are slightly visible, then the BCS is 4.25. If the pin bones are full of fat and no angularities (bony protuberances) are observed, the BCS is 4.5. If the hips are slightly visible, the BCS is 4.75. If the animal does not have any bone structure or visible bones, the BCS is 5.0. Cows with a BCS of 4.25 or higher should be rare cases. If a large percentage of the herd has a BCS of 4.0 or more, nutritional and overall herd management should be evaluated and corrected urgently.

Table 2.1. Ideal ranges of BCS at different stages of the production cycle of dairy cows.

Stage	BCS cows	BCS Heifers
At calving	3.25-3.75 Ideal 3.5	3.0-3.5 Ideal 3.25
30-90 days postpartum	2.5-3.0 Ideal 2.75	2.5-3.0 Ideal 2.75
150-250 days postpartum	2.75-3.25	2.75-3.25
At dry-off	3.0-3.25	n/a

Fecal score

The evaluation of feces is a quick and effective method to determine the functioning of the whole digestive tract from the point of view of dietary management. However, its interpretation must be considered with caution since there are many infectious or toxic conditions, such as mycotoxins, that can also affect the consistency and appearance of feces.

A chart that has defined a fecal score for cows managed in different production systems is a tool that can help monitor the nutritional and feeding management of dairy cattle. However, this score must be adapted to the type

Figure 2.4. Fecal score chart for cows fed total mixed rations

 SCORE 1	 SCORE 1.5
 SCORE 2	 SCORE 2.5
 SCORE 3	 SCORE 3.5

SCORE 4

Source: Ireland-Perry and Stalling (1993)

of feed the cow receives. The type of feces in herds fed with TMR is completely different from the type of feces of cows fed on pasture. In cows fed with TMR, the consistency of the feces is associated with the NDF and starch content of the diet and therefore with the type of ruminal fermentation indicative of a normal process or a subacute and/or chronic acidosis process. On the other hand, the consistency of feces is also associated with undesirable fermentations that occur in the cecum of cows because of starch bypassing the rumen, in diets with a high starch content and/or poorly processed grains that ferment in the posterior digestive tract.

Fecal score will vary based on the stage of the production cycle. Early dry cows will show dry feces with more consistency than prepartum cows and so on. This is reasonably explained because of the dynamic change in the content of NDF and starch from early dry to fresh cows. Starch increases from early dry to postpartum cows whereas NDF decreases, altering the rumen fermentation process to more production of total VFA and change in the molar proportions of rumen acids with more propionic than acetic acid and more lactic acid. In addition, the fecal score can also be affected by a more noticeable cecum fermentation from dry-off to freshening.

TARGET

- Early lactation: 2.0 to 2.5
- Medium- late lactation:2.5 to 3.0
- Early dry period: 3.0 to 4.0
- Prepartum period:2.5 to 3.0