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Edited by Charles H. Carter, Jr.
Israeli School For Dairy Farming Technology

Learn how the Israeli cows produce 12,000 Kg of milk a year

Introduction:
Dairy industry is a leading sector in Israel agriculture. Average milk production per cow has increased since the 1950s' from 4,000 kg annually to more than 12,000 kg of milk in 2010. Fat and protein percentage increased dramatically. The dairy sector fully serves the country’s total dairy needs.

Israeli advance dairy technology:
Israel's dairy industry use most advanced technologies include computerized milking and feeding systems, cow-cooling systems (to reduce heat stress on cows in the hot and dry summer), as well as milk processing equipment.

The seminar:
You will learn how the achievements of Israel's dairy sector have been made possible and how Israel succeeds in increasing of the production efficiency. You will visit two types of dairy farms:
• Family farm, with 40-50 milking cows;
• A kibbutz dairy cooperative, with 300-400 milking cows.

Main topics of the seminar program:
• An overview and recent developments of the Israeli dairy industry
• Modern management technologies in high producing dairy herds
• Nutrition management and feeding principles
• High yield production under hot climate and heat stress conditions
• Breeding and fertility management
• Economic aspects of management of dairy herd
• Milk quality and udder health
• Raising calves and heifers
• Health and prevention of diseases
• Visit the Israeli Insemination Centre and the Cattle Organization
• Visit a software manufacturer for dairy farm management
• Visit a Cow feed center and Feed mill

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Preface
This study deals with the principles of nutrition management is based on the experience and knowledge I have acquired as a dairy farmer and dairy farming consultant for almost fifty years. As a child, I had the good fortune to be able to ride the donkey, carrying two churns of milk to the milk collecting station. Today, computers controlling sophisticated electronics oversee the milking process. Everything has changed. The cow, which is the subject of this study, has been genetically improved, but basically, it is the same cow. There was a time when we produced milk to provide us with something to eat. Today, here in Israel, and in many other dairying countries, milk is not only a basic foodstuff; it is the raw material for a vast range of milk-based products. Then and now, the dairy industry keeps the farmer chained to his tasks 24 hours a day and that is the reason why we must continue searching for ways to provide the farmer and the cow with a more comfortable and efficient lifestyle.

This is not a dry scientific work filled with facts and references; it does not present all the facts. This is an attempt to present examples and practical solutions for the day to day operation of a dairy, spiced with the appropriate solutions of scientific thinking. I can only hope that I have succeeded and that is for the reader to judge.

Understand this: The various models published by committees in different countries around the world are from my point of view, something akin to travel guides for tourists. Whereas practical planning will make use of the model, it must always take into account the limitations imposed by time and space. Reality will present the user with something different, which very often; will not conform precisely to the model.

An expert in nutrition once reacted to a statement I made with: “Where is that written down?”

My response:

“It is my personal knowledge gained through experience. I do not act without reason; there will always be a scientific background accompanied by an additional dimension garnered through practical experience. If I was wrong, I learned the lesson taught thereby and reached the appropriate conclusions. I believe in this method as the best way forward. “

We have learned of the global trend towards fewer and larger herds to think differently. Regrettably, professional literature (and a limited number of studies) provides insufficient data about herd nutrition. Therefore, we must develop our own understanding of the issue (cow nutrition) that will most effect our lives as dairymen.

Editor’s Note: To correctly view graphs, resizing of e-reader text may be necessary.
Management, Not Nutrition is the Cornerstone to Dairy Herd Management

Nutrition experts often tend to think that success is attained simply by using the appropriate components to balance the diet and complying with all the recommendations issued by committees.

Economists focus on the price of food, the market conditions and the high costs incurred for the construction and maintenance of dairying infrastructures. Veterinarians, breeders and inseminators also have their own separate, specific perspectives. Each of these perspectives is limited in scope. A wider view is needed.

The question of nutrition, the quantities supplied and use may be compared to the fuel powering a vehicle. It is just fuel. A good journey in a quality and well maintained vehicle also requires a proper road and a good driver.

Twenty-Nine family dairy farms, essentially identical, received the same rations and used the same veterinary and insemination services. One year’s entire production was measured, and the average yield was 9809kg of milk per farm. Each of the farms had forty (40) cows with results ranging from 8,890kg to 10,754 kg of milk. The range of nearly 2,000kg is solely due to management practices.

Good food and balanced rations are only building blocks for the system, but their use and management is just as important.
**Introduction**

Ruminants (cud chewing hooved animals) in general and dairy cows in particular are herbivores. Close examination of the structure of ruminants’ digestive systems reveals that they could easily be defined as carnivores.

Plant based food serves as the dietary substrate for a broad range of microorganism populations in the stomach. Single cell organisms of various types (bacteria, protozoa, etc.) help break down the vegetation eaten and use it to build their own bodily tissues. At the same time, they secrete various compounds into the stomach juices, conduct a vigorous sex life and propagate.

Biologists know how to characterize the different natural proteins (which are the building blocks for all animal tissues) according to each protein’s “biological value” to the consuming animal, which are used to measure the level of efficiency in which a food protein can replace the body’s protein.

<table>
<thead>
<tr>
<th>Type of Protein</th>
<th>Biological Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>98%</td>
</tr>
<tr>
<td>Milk</td>
<td>95%</td>
</tr>
<tr>
<td>Meat</td>
<td>85%</td>
</tr>
<tr>
<td>Vegetable (Leaf)</td>
<td>70%</td>
</tr>
<tr>
<td>Vegetable (Legume)</td>
<td>50%</td>
</tr>
<tr>
<td>Microorganism</td>
<td>85%</td>
</tr>
</tbody>
</table>

The biological value of microorganism protein is 85% , comparable to meat.

**Microbial Activities and Nutrition in the Ruminant**

Digestion breaks down the low value food protein into high value microbial protein. Growth in microorganism populations and secretions create volatile fatty acids (VFA) which are absorbed into the blood through the stomach wall and constitute the animals’ principal source of energy.

Ruminant nutrition is a complex process, not yet fully understood. We know that it is important to maintain balanced nutrition, and that the balance should be maintained unchanged over the long term. Persistent nutrition is an important factor in dairy success.

The modern, high yielding cow is essentially no different than its predecessors that gave only small quantities of milk sufficient to feed their offspring and depended on the availability of food.

Man has learned to produce food products from the cow for human consumption through the combined use of genetics, management and feeding. However, the need to preserve the unique functioning of the ruminant digestive system to turn any organic material into milk and meat, remains the focus of all work on the dairy farm.
Natural grass as sole feed cannot support very high milk yield. To raise yields, it is possible to add to the ration additional products that survive the digestion process in the rumen and absorbed directly through the omasum (the real stomach), such products help raise the efficiency of microbial activities and/or the metabolic processes in the cow’s body.

Microbial protein and breakdown products from the microorganism populations are the natural, optimal food for cattle; they provide all the cow’s needs at an average level of production. When a maximum yield is desired, food additives and foods high in protein and amino acids (which do not break down in the rumen and move on intact to undergo enzymatic decomposition in the intestines) are needed. In all circumstances, the dairy farmer must ensure the cow’s welfare and must balance the raw materials provided in the feeding trough as a function of optimal microorganism growth.
The Physical and External Factors Influencing Nutrition Efficiency

Extreme heat or cold affect cattle behavior and nutrition efficiency. Wind and humidity contribute to the heat load. Optimal dairy conditions are in the range of 20°C - 25°C, with humidity between 30% - 40%. Any rise in humidity levels, even at low temperatures, will have an adverse effect on behavior and milk production. In cold weather, where temperatures drop below freezing and with stronger winds, the cows need to produce heat increases which have a detrimental effect on the efficient use of food for milk production. Hot and dry weather, with humidity below 15%, will also reduce production. Shade and a pleasant breeze will help provide the cows with relatively comfortable conditions.

Nutrition management for a dairy herd is the an expression of all we have learned about food composition and quality, the needs of livestock, environmental conditions, climate, structures, animal maintenance and comfort. Beyond all those issues, nutrition management expresses what we have learned about the animals’ ability to reach food, consume the quantities they require and how to produce the maximum amount of milk and meat while maintaining their condition, health and fertility. All that must be done with high efficiency and profitably, thereby providing the farmer with a livelihood.
The Digestive System

The digestive system of ruminants is different from single stomach animals (humans, pigs, etc.). Anatomically, the rear part of the esophagus of ruminants is wider and is what we term the fore-stomach. The fore-stomach is a large fermentation tank about one third the size of the cow’s entire body. Traditionally, the fore-stomach is divided into three parts: Rumen, reticulum and omasum. Most of the microbial activities take place in the first two stomachs, the rumen and the reticulum; the omasum squeezes the semi-digested food before moved it into the true stomach.

“Rumen” is the term referring to the three parts of the fore-stomach. The fourth in this series of stomachs is the true stomach, which constitutes a mere 7% of the entire stomach system and it functions in a manner similar to that of all other animals (except for some slight differences in birds).

Mothers teach their children to chew before swallowing. Ruminants do it the other way round. They swallow, fill the rumen and only then find somewhere safe and comfortable to rest, regurgitate their cud and chew. (It is likely that this is a defense mechanism against predators. Assuming that in nature, food could be found principally in exposed grassy areas, they could hide to digest the gathered food.)

Food consumed without chewing causes finely sliced food particles to sink to the bottom of the rumen, while longer fibers float and/or sink only slightly into the rumen juices. The longer pieces of food create a latticed layer which prevents the smaller particles from sinking quickly to the bottom of the rumen and passing into the duodenum and small intestine before they can be broken down by the microorganisms. Once further along into the system, they cannot be broken down and in their undigested form, they pass into the feces.

The cow copes with foods rich in long fibers by having it spend a longer time in the rumen. This gives the microorganism populations in the rumen enough time to break down larger quantities before it leaves the rumen and enters the other sections of the digestive system. The extended delay also contributes to the rise in digestibility and it improves the digestibility of the entire diet.

Food breakdown in the rumen creates methane and carbon dioxide, which although not digested, cannot be found in the feces. This must be taken into account when conducting digestion experiments.

Long fiber food stimulates the area where the esophagus meets the rumen and the reaction to that stimulation is similar to the process that occurs when a human vomits. The unprocessed food returns to the mouth, where it is chewed and that process is repeated again and again. The cud regurgitation process serves a number of very important purposes.
First, the unprocessed food returns to the mouth for chewing and slicing and during that process, it becomes accessible to the microorganisms. Next, the cud stimulates the animal to secrete saliva which contains salts that regulate the rumen’s acidity. Gases produced during the fermentation process in the stomach are released during the regurgitation of the cud.

To summarize, the fermentation products in the stomach are:

1. Microorganism bodies, built up from the broken down food.

2. Acids and ammonia, defined as “waste”, which can absorbed and exploited by the microorganisms and/or the ruminant.

3. Gases, such as methane and carbon dioxide.

4. Heat that is created during the fermentation process.

5. Remnants of undigested food, such as undigested fibers, which are excreted in the feces or protein compounds that have survived the microorganisms’ activities. After reaching the intestine they can be digested by animals. This will be discussed in the section dealing with proteins.

The food components which may be used by the cow include microorganisms, the “fermentation wastes” and the residual protein. Heat and gases usually constitute a danger for ruminants and they must be disposed of by expelling them from the body. After expulsion from the animal, they become environmental hazards. Real digestion will be discussed later because it is a vital factor in the understanding of the digestive process and nutrition.

The vital importance of long fibers lies in the way that they prevent the accelerated flow of food through the digestive system, which in turn improves digestibility and helps save the lives of the cattle. Alternatively, too much long fiber food in the diet has a detrimental effect on food consumption as the rumen fills more and the flow of food slows down. Consequently, there is a drop in the quantity of food passing into the intestines for digestion and a drop in production. Proper balance is necessary for good nutrition. Balance means the correct ratio between the different sources of food in order to maintain the required level of food consumption, without harming digestibility. Food consumption rates is one of the limiting factors in ruminant nutrition.

Digestibility and food consumption sometimes appear to be contradictory. The secret of good nutrition is to find the balance between the two. (A healthy, producing cow needs 550 - 600 minutes in every 24 hours to regurgitate cud). Any investigation of rumen and digestive system functioning must take into account the types of food, their chemical composition and physical structure.

The link between a type of food and its chemical composition is measured in terms of its breakdown rate and percentage in the rumen. Young vegetation is high in protein, low in lignin
and breaks down faster. If it is the only source of roughage, large quantities must be provided. If not, the rumen will not function properly due to an insufficient excretion of saliva; rumen acidity will rise (pH will fall) and a highly acidic stomach will cause severe health problems for the cow. Problems include low levels of food consumption and damage to the epithelial tissues which line and protect the stomach wall. Other problems include a detrimental effect on hooves, limping and more.

High levels of starch (mainly starch from degradable and soluble food sources) which are low in fiber create the same problem.

**Increasing the proportion of high energy foods in the ration to increase dairy production has the opposite result.**

The balanced ration is the ration with the correct balance between forage with a fibrous structure and higher energy forage, which lacks the fibrous structure and is a combination of all the food carbohydrates that break down rapidly and spontaneously (Non-Structural Carbohydrates – NSC).

The higher the quality of the forage available to us (measured primarily in terms of non-digestible lignin), the lower the need for any addition of concentrates (grains) to the ration. The opposite is also true. When feeding straw and lignin rich foods in desert and tropical areas, if the ration is not balanced by feeding grains and other concentrates, we might be forced to compromise on lower cow yields and if that is the case, we will try to make maximum possible use of locally available raw materials.
**Food Consumption**

Dairy herd management, cow behavior and the cow’s genetic makeup (small or large cow from a milking line or of mixed descent, etc.), the dairy farmer and all that together with the selected range of foods, must be expressed to the full in terms of optimal consumption of food. Food not eaten will not be digested and will not make the expected contribution. Many factors combine to determine the quantity of food eaten. Every researcher and committee has its own formula, but does one formula fit every herd?

Most of the advanced prediction formulae focus on cow’s weight, milk yield and composition (more fat in the milk means more energy expelled from the body) and the lactation stage, all in an effort to cause a rise in consumption from the calving date up to 40 – 60 lactation days, followed by a steady fall in consumption towards the drying off period. In order to simplify the various models, some do not include factors such as fiber content (NDF), source or texture. Most researchers assume that cow performance in terms of milk yield, growth etc., are true expressions of the ration and its composition and therefore, they see no need for specific characterization of the constituents in the ration.

The physical structure of the ration (fiber length) influences consumption. Long fibers reduce food consumption and the opposite is also true for chopping, particularly excessively short chop length. When the chop length is too short, it can cause the opposite effect and lower consumption due to higher stomach acidity, which reduces the level of microbial activity and in some circumstances, can cause SARA (Sub-Acute Ruminal Acidosis). In more acute situations, it can lead to the death of the animal.

When food fat levels are higher than 5-7% of the total ration, digestibility is depressed and consequentially, consumption drops. Climate, food delivery regimes (delivery frequency, how often it is pushed up the food given and the times during the day that these activities are performed) contribute towards higher consumption as a function of the frequency at which they are performed. Feed push up and delivery timed close to the cows’ exit from the milking parlor and their return to the feeders have particular importance. Food delivery during the cool hours in the summer also contributes to higher consumption.

For example: Two consumption prediction formulae:

The first formula is as recommended by the NRC 2001 committee. This formula places particular emphasis on consumption prediction based solely on cow data (body weight, fat corrected milk, and the time from calving):
DMI (kg/d) = (0.372 x FCM + 0.0968 x BW^{0.75}) x 1-e^{(-0.192x(WOL+3.67))}

When:

DMI = Dry Matter Intake
FCM = Kilograms of 4% Fat Corrected Milk
WOL = Week of Lactation
BW = Body Weight in kilograms

The consumption prediction formula adopted by the NRC might be less accurate, when the ration includes high levels of buffers, particularly in those areas where most of the forage is green vegetation, which breaks down quickly in the rumen and therefore exits the rumen rapidly. The opposite will be true when various organic residues are included in the ration and in those tropical areas where most of the available foods are high in lignin.

The authors of the NRC formula determine that: “Less than 1% of food consumption variation is influenced by the cell wall – NDF”. In their opinion, cow performance is an accurate reflection of ration properties. Unfortunately, I find that statement difficult to digest.

Alternatively and to emphasize another approach, which also takes food data into account, it is worthwhile presenting the proposal made by Mertens in 1984. In this prediction formula, the cow’s energy requirement is divided by the concentration of energy in the food and it is displayed as follows:

$I = \frac{NER}{NE}$

When:

I is food consumption measured as dry matter
NER = Energy requirement
NE = Energy concentration in the food

The NER value is calculated as follows:

$NER = 0.08(BW^{0.75}) + 0.74(FCM) - 4.92(LOSS) + 5.2(GAIN)$

When:

BW = Body Weight
FCM = Kilograms of 4% Fat Corrected Milk
LOSS expresses the supply of energy from the body fat layer, which takes place as mentioned earlier, during the initial period after calving.
GAIN is the value that must be added for the weight gained during the rest of the lactation.
Calculation of NE is based on the estimated energy supplied by concentrates rich in unstructured carbohydrates, together with energy value of the fiber rich food in the ration, which takes into account the quantity, nature and composition of the NDF (see: Chapter 6).

Once again, this formula is simplistic because it does not take into account the cow’s bodily condition and other management regime factors, such as the feed mix, feed delivery, the physical structure of the food and more. Both formulae will be able to serve as a general standard, but they will not be helpful to the dairy farm or to an individual cow.

For example:

One dairy reported: “milk yield has dropped and the cows are refusing to eat.”
A brief examination revealed that the dry matter level in the silage was higher than planned. Dry silages have an adverse effect on consumption because it is difficult to chop properly during harvesting which makes it difficult to compact the silage in the pit. Consequently, the silage spoils easily.

Another instance described and solved:

“I was once invited to take part in a discussion on a drop in food consumption and milk yield; I found that the silage had been harvested at too high a moisture level and there was a large volume of run-off from the silage pit. Once more, the problem was solved by replacing some of the silage with dry forage without replacing the silage entirely; the silage was and remained inedible.”

When silage is too wet, it reduces food consumption because of the high level of water in the cells and excess acidity.

During normal dairy farm work, all factors must be monitored on a daily basis. One of the problems, which must be re-examined, each time we review ration structure and food consumption, is the (sometimes) reciprocal relationship between digestibility and the rate of food decomposition in the rumen.

A balanced must be kept between encouraging consumption (providing the cow with the as many nutrients as possible) and feeding easily digestible foods (their high flow rate through the digestive system causing loss of digestible food into the feces). These considerations should be made when selecting the foods to use, the treatments to apply to the different foods, and the reciprocal relationships between the two factors.
Food Components

Carbohydrates
The fiber system makes it possible for a plant to rise out of the ground and stand upright. It is customary to examine the components of this system through the structure of cell walls and the adhesive that keeps them together. The basic structure of food fibers comprises a chain of carbon (C) atoms, with hydrogen (H) and oxygen (O) atoms alongside the carbon. The links within the chains and the strength of those links, determine the nature and properties of the substance.

Starch is a carbon fiber, which breaks down relatively easily in an aqueous environment or it can be broken down by enzymatic activity in the digestive system. In plants, starch serves as the energy reservoir stored in seeds to ensure germination. When the seed is supplied as a foodstuff, starch constitutes a good, rapidly available source of energy for the animal. Starch from different vegetative sources has slightly different properties. Wheat and barley starches break down rapidly in the rumen’s aqueous environment and make major contributions as a source of energy for microbial activity. Maize (corn) and sorghum starches break down slower and therefore, they persist longer, which means that most of the absorption of those starches into the body is through the intestines where they serve as available energy sources. Fine chopping of maize and sorghum grains into very small pieces increases the rate at which they are absorbed through the intestine.

Cellulose, which has a basic structure similar to that of starch \((C_6H_{12}O_6)_n\) and hemicellulose (a different chain, which contains a combination of 5 and 6 atoms of carbon) are more stable and their breakdown is dependent upon the populations of microorganisms in the rumen.

Lignin is another component in fiber, present in much lower quantities, but has a powerful effect on both the plant and digestibility. Lignin is not a carbohydrate in the commonly accepted sense. Lignin is a complex structure, or a chain of rings, some of which contain nitrogen. Lignin has a much more stable structure than cellulose and hemicellulose; lignin is not digested. (During the discussion of proteins, we will explain that anything which is not lignin, but is close to or and/or bound to lignin such as the nitrogen in the rings, also has degraded digestibility). Lignin levels in plants rise with the plants’ age; accordingly, young plants have much higher digestibility than mature plants, notwithstanding the fact that laboratory tests often characterize these fiber components as carbohydrates; no difference is apparent between the different plants. Research into lignin is somewhat problematic because we don’t always know if it appears in specific locations in the plant or is dispersed throughout the plant. (If lignin is dispersed within the plant tissues, the plant links relatively greater percentages of digestible plant parts to the lignin, when compared with that found in plants with lignin as a continuous physical presence).

Other food components, such as fat and protein are found within the cell itself and shall be discussed separately. However, the material between the cells contains varying levels of pectin, which is a chain of rings that breaks down easily and that is its major contribution to the food’s energetic value. We must point out that whereas pectin is present in only tiny quantities in green
leaves, it is present in relatively large quantities in fruits and that is why food industry wastes such as citrus peels are of such high value to the ruminant industry.

Characterization of the cell wall allows us to differentiate between the different plants according to their physiological age and also helps us differentiate between fiber rich food and concentrated food – grains have higher starch content than cell walls; in leaves and plant stems, cell walls are present in significantly greater quantities.

Wood stems and grains have similar carbohydrate content with the exception of a small difference in mineral concentrations – ash. The differences in the nature of the carbohydrates in the different plant parts means that the grain is a high energy, concentrated food, while the stem is high fiber roughage, which (in the rumen) serves to support digestibility and slow breakdown by the microorganism populations.

To characterize the fibers in the laboratory, we must differentiate between the cell wall (NDF), which is an expression of the remnants from the test after steeping the plant in neutral solvents (alkaline and/or detergents with a pH of more than 6) and it includes all the plant fibers, which as stated above, are: Cellulose, hemicellulose and lignin. There are those who also include pectin in this list, despite the fact that it breaks down easily in the rumen in a manner more similar to starch. However, it does break down during the treatment with the neutral solvents. The remaining NDF is treated with low concentration, weak sulfuric acid (1.25%), which separates the hemicellulose from the cell walls and provides the value: Acid Detergent Fiber – ADF. A number of laboratory techniques can be used to separate between ADF and lignin and naturally, they provide different results. Customarily, nutritionists examine the lignin content by treating the remnants with high concentration, strong acid (72%), which provides the value: Acid Detergent Lignin – ADL. Botanists examining the plants not from the nutritional aspects employ a different range of techniques and it would seem that they are more accurate. The most stringent transfer the ADL remnants to an oven at a temperature of 550ºC to burn the remnant down to ash (the range of minerals).

Lignin digestibility is very low or non-existent. Simply, check the lignin content to know the nutritional value of the plant.

The problem is more complex because the lignin is not a single entity. When examining the nutritional aspect, remember that not all the lignin is characterized as part of the ADF and some of the lignin breaks down in the presence of the alkali and is not included in the final results.

Given that some of the plant lignin breaks down in the alkali and some more lignin breaks down in the acid, it is difficult to predict the link between ADL content and cell wall digestibility – NDF.

Despite the difficulties encountered during laboratory characterization, we can use ADL to predict cell wall digestibility when comparing plants harvested at different stage of maturity,
knowing that the younger the plant, the greater the digestibility. It is difficult to predict cell wall digestibility using ADL when comparing plants which are botanically different.

Apart from the ADL technique, there are other techniques that can be used to characterize lignin. The alternative technique most often used is the KL test, which instead of trying to separate between lignin and cellulose using strong acid as in the ADL test, uses potassium permanganate (KMnO₄) to oxidize the ADF. When using this test, the results are higher than those received from the ADL test and that can be reasonably attributed to the nature of the test, which successfully includes not only the non-digested fibers in the cell wall; it also comprises some of the lignin that breaks down in an alkaline environment, which is the non-digested component found inside the cell. Chemically, the difference between ADL and KL is that part of the lignin comprised entirely from less stable materials (phenolic acids). In fact, the characterization of this lignin component can teach us more about plant dry matter digestibility when comparing different plants, or the same plants from different plots of the same age. On the other hand, when examining a specific plant at different growth stages and from different growing areas, it would seem that the ADL test suffices.

Starch and sugars constitute the cell-content carbohydrates and in the overall characterization, they are usually defined as NSC (Non-Structural Components) with high solubility in the rumen. On the other hand, in terms of the difference between the two lignin characterization methods, we learn that not all cell content components are soluble, digestible and high in available energy – ADDL (Acid Detergent Dispersible Lignin).

Predicting the digestibility of the cell wall using the ADDL technique is very significant in the case of cereals and principally, in the case of cereals growing in and/or sourced from tropical areas. In contrast, when assessing legumes, the simpler and easier, ADL method is usually up to the task. The next stage in the decoding of the secret of forage will be slightly more accurate and will include as a matter of course, both the ADL and the KL tests.

Despite the limitations of the test, it would seem that in on the farm, regular measurement of ADL levels could significantly improve the ability to provide the correct combination of the forages at our disposal. The negative effects of lignin on digestibility are not linear; lignin has an aggregate effect. Therefore, a plant with a 4% ADL level is far less digestible than the same plant with a 2% ADL content (1% out of 2% lignin has less effect on the drop in digestibility than 1% out of 4%). Thus, in the case of lignin rich foods in which the digestibility damage has already been done, it doesn’t matter if the lignin is 30% or 40% of the plant or even higher. The range of interest to us and to which we must pay close attention, is between 2% and a maximum of 8% (it is standard practice to assess loss of digestibility at 2.4% for every 1% lignin).

Cell wall digestibility (NDF) constitutes a core measurement in the prediction of ration efficiency for ruminants on milk yield. Recent years, with the growth in the use of low lignin varieties of maize and sorghum (BMB – Brown Midrib); have seen the publication of large
numbers of studies on the very considerable contribution that these varieties make to the dairy farm. Careful selection of the harvesting date for the varieties in regular use will achieve similar results.

The fiber tests described here constitute the basis for most of the research into nutrition. Unfortunately, these tests do not provide enough detail about the various components of the plant. It would seem that for the purposes of characterization of food at the farm level, the standard NDF method described suffices for this purpose.

For day to day life on the farm, it is not enough to know the chemical composition of the plant. Its physical structure and its ratio in the ration are of very considerable importance. Researchers in Pennsylvania developed a sieving system, which can be used to characterize food fibers according to length. When a fiber is shorter than 1.18mm, it will not be defined as effective, because it has no influence on rumen activity and the regurgitation of cud. It is important to emphasize that the effectiveness value found is also a relative figure and it is impossible to compare between plant parts with an average length of 2cm and other parts with an average length of 4cm, 6cm and more.

The percentage of effective fibers in the food influences the consideration, which must be given to the overall cell wall data for that food and the degree to which it can influence digestion processes. Definition of food in “rougahge units” can help us understand this subject (the calculation: Fiber longer than 1.18mm x %NDF).

For example: Whole crop cereal forage with an NDF of 65% and 98% long fibers, will have 63.7% effective fibers. Using the same calculation, maize silage with an NDF of 50% contains just 41.5% effective fiber. Crushed soya husks, notwithstanding the fact that they have an NDF of 67%, had just 0.03% particles with a length of more 1.18mm and therefore, the level of effective fiber in this silage was a mere 2%. This issue is also important in grains. After physical treatment and due to the nature of the grains, it was found that rolled barley contributes more effective fiber than finely ground maize grain, etc.

Despite the wish to determine an objective yardstick as is true for effective fiber, it was found that two foods with identical fiber length, but a different cell wall composition will not behave in the same way in the rumen, apparently because each food has a different breakdown rate in accordance with its composition and properties.

Effective NDF values can also be used as a measurement of rumen filling (Fill Value) and therefore, it is standard procedure to apply this measurement to the different cow rations and when the NDF for the ration rises above 30%, the rumen fill value also rises. Consequently, both the flow of digested products through the digestive system and food consumption drop.

Another important consideration, which must be taken into account, is the region where the plant is grown. On a visit to Florida, I saw beautiful alfalfa in the feed bunker. I expressed wonder and
the fact that I had not expected to see such high quality feed in such a warm, moist area. After asking where the alfalfa had come from, I was told that it came from Utah, a state which benefits from a dryer, colder climate than Florida. Utah is further north on the globe and therefore, plants are less woody and they are easier to digest. It is also true that even in small countries like Israel; there are no similarities between northern and southern plants. The same is true when comparing winter grown to summer grown plants and when comparing plants, which are botanically identical, but have been grown in hilly or valley areas, or in the Syrian – African Rift valley below sea level.

Testing was conducted to reveal the chemical composition of several forage varieties of wheat, grown for two different harvesting dates in two adjacent geographical regions – one was a mountain plain at a height of some 300 – 400 meters above sea level and the other was in the Jordan Valley, some 200 meters below sea level. The ADL/ADF ratio, which is a good enough expression of fiber digestibility for the plants harvested at the flowering stage, was 18.05 on the mountain plain and 20.40 for the valley crop. The plants harvested at the milky grain stage had ratios of 21.47 and 23.37 respectively. Later maturing plants at the flowering stage gave ratios of 16.16 on the mountain plain and 20.76 in the valley. At the milky grain stage, the late maturing plants gave ratios of 16.92 and 27.84 respectively.

The conclusion: It is essential to match the variety to the growing area and preferably, early maturing varieties will be grown in the warm areas and late maturing varieties in the higher, colder regions further to the north.

Another study in Israel, (Ben Sedalia) which examined fiber digestibility for wheat silage made using early and late maturing varieties, found a difference of 6.1% digestibility between the flowering stage and the grain filling stage in the early maturing varieties, but just 2.2% in late maturing varieties. Late maturing varieties are less woody than early maturing varieties.

Protein is the subject of the following chapter.

**Protein**

Proteins, like carbohydrates, are carbon chains, but protein chains also have links to nitrogen atoms. A simple protein chain is comprised of short units combined with a small number of carbon based structures called amino acids. When the chain is more complex and has a slightly higher number of carbon structures, it is called a peptide. In practical terms, a protein is a chain of different amino acids, connected together in a fixed, specific sequence. The relationships between the various acids and their position in the chain determine the protein’s size and properties.

Protein structure and the nature of the links within the chain or between different chains have an influence on protein stability and microorganisms’ abilities to break them down for their own needs. Ruminant nutrition differentiates between rapidly broken down, soluble proteins and
proteins which can be broken down only through the intercession of an external factor, such as microorganisms.

The definition of protein is divided into two groups of proteins, which we shall call the degradable and soluble groups. Part of the protein survives the rumen and is whole when it reaches the intestines, where it is digested by the animal’s enzymes. Some of the protein that survives the rumen can be degradable protein, which was not digested due to the rapid flow through the system. Protein reaching the intestine undergoes digestion by enzymes in a process similar to single stomach animals. Protein is not digested in its entirety in the intestine for a number of reasons:

1. Due to the speed at which food is washed out of the rumen and passes through the digestive system, the degradable protein can continue on and flow out in the feces.
2. Protein bound to lignin (ADIN) cannot be utilized.

To complete this process, it is important to mention the wear and tear caused by the passage of food through the digestive system. Body protein worn away from the walls of the digestive system passageways, together with the enzymes secreted from the body, constitute between 3% and 5% of the nitrogen in the feces (metabolic fecal nitrogen) and the rougher the ration (straw) the higher the quantity of nitrogen excreted. On the farm, it is customary to disregard the value of foods containing up to 3% protein as a source of protein. They are sometimes listed in the ration planning charts as having zeroed or negative protein value. The protein that is present is inefficient, residual protein. To complete the picture of nitrogen balance in the body, we must mention the excretion of nitrogen in the urine, which is the byproduct of metabolic processes in the body and not only the excess nitrogen excreted as urea. The quantity of metabolic waste (endogenic nitrogen) is not large, but must be taken into account when conducting digestion experiments.

Notwithstanding the fact that food protein is essentially a carbon chain, it is an inefficient source of energy. Protein’s vital role in food is to build body tissues and help produce milk; it is not worthwhile to provide protein in food as a source of energy. Protein is an inefficient source of energy because despite the fact that it is an energetic material, it breaks down into an intermediate material – non-protein nitrogen, which contains some of the energy intrinsic to the protein (equivalent to some 1.25 Kilocalories for each gram of digested protein) and most of the non-protein nitrogen is in the form of urea. Although rich in nitrogen like protein, the urea molecule has no residual oxygen, which could to a degree, serve as a food substrate for the rumen populations to make microbial protein. The residue comprises short chain molecules, which are absorbed to a not inconsiderable degree through the rumen walls into the bloodstream and they are not utilized either as a source of energy or as a source of nitrogen in the making of microorganism protein. The residue is excreted as urea in the urine and therefore, notwithstanding the fact that it is a digestible material, in practice its digestibility is a fiction or artificial.
Regrettably, various committees for the determination of nutritional norms tend to ignore this finding and they determine a direct link between digestibility and energy, without deducting artificial digestibility, even though they do take this finding into account when discussing the nitrogen balance in the body.

In real life, the food ration is balanced using overall protein units (N x 6.25), which is the mathematical expression used to translate the quantity of nitrogen found during laboratory testing into a quantitative measure of protein, because in most vegetative raw materials, nitrogen constitutes 16% of the total material (100 ÷ 16 = 6.5). Current knowledge allows us to differentiate between the three types of protein mentioned above: Rapidly broken down soluble protein, degradable protein and survives protein. The most practical recommendation for ration preparation is to provide all three types in a 1:1:1 ratio. Rumen populations (assuming a ration balanced for fiber and available energy) have the ability to exploit the two sources of protein that break down in the rumen for microbial protein. Unfortunately, this capability has limitations. One third of the protein supplied in the ration, which is the proportion that survives the rumen, is exploited by the animal using the enzymatic system and it does not exploit the non-utilizable protein (ADIN).

For any given nutritional composition in a ration, advanced models can be used to calculate the total amount of protein absorbed through the intestine, which comprises utilizable residual protein and microbial protein. This combination, together with various models used to predict the composition and quantities of different amino acids absorbed into the body, expresses the real value of the protein in the food, which is then defined as Metabolic Protein – MP.

The dairy farmer should plan the supply of protein in the ration by calculating the Metabolic Protein value of the food. Unfortunately, in many circumstances it can only be used for the theoretical examination of the ration, using different models.

“A veterinarian very interested in nutrition models once called me and asked: ‘If a ration for calves needed no more than 12% overall protein to provide all the required Metabolic Protein, why are we wasting protein and providing 13% - 14% crude protein in the calf ration?’ We met and together we examined an advanced model. It showed us very clearly that the link between overall protein and metabolic protein is a function of ration composition. In the case that we checked, by making only a few changes in the range of raw materials in the ration, we successfully predicted identical production of metabolic protein (MP) in rations containing from 12% to 19.5% crude protein.”

Any discussion of protein quality and its contribution to ruminants cannot be limited solely to chemical characterization. It is always important to take a close look at the conditions, which contribute towards the production of microbial protein. Available energy is a vital factor in the process. Different plants, such as legume forage, which has a high proportion of leaves, will encourage more vigorous production of microbial protein than various cakes, which are the main...
protein source in standard rations. For example: Soya protein breaks down in the rumen slower than alfalfa protein. On the surface, that would imply that it is a better protein. In fact, it is the alfalfa protein, which contributes more to the production of microbial protein than the soya protein. Therefore, the soya protein is exploited less efficiently, and relative large percentages of soya protein pass into the bloodstream and the body as ammonia. During digestion experiments, it is included as digested material, but its artificial digestibility makes no contribution to the supply of either energy or protein to the animal. Such proteins even consume energy to expedite its excretion in the urine or in the milk. In other words, we can reasonably say that soya protein (and similar foods with greater effect, such as gluten feed and others) makes a relatively large contribution to the artificial digestibility compartment.

The nitrogen cycle within the body does not result in the excretion of all the surplus nitrogen in the urine. Some nitrogen returns through the saliva into the rumen. Nitrogen in the saliva joins the overall nitrogen in the rumen, most of which comes from the food. Some of the nitrogen was in the food when it was consumed at the feeding trough (even alfalfa protein contains a certain amount of ammonia). The remaining nitrogen, which is also the larger quantity, is real food nitrogen, which was broken down in the rumen because rumen microorganisms had neither the energy nor sufficient time (due to fast breakdown rate and speed of digesta flow through the digestive system) to use the ammonia to make microbial protein.

Many of us now have a practical tool to estimate artificial digestibility – measuring the quantity of urea in the milk. The starting point for this process is as explained above: The ammonia and nitrogen in the rumen not used to create microbial protein. As it continues, they enter body tissues, where they are transformed into urea. As the urea concentration in the blood rises, it moves on and it is absorbed into the milk.

What have we learned from all this?

A high concentration of urea in the milk is a characteristic indication of an imbalanced ration and principally, its lack of available energy for the efficient exploitation of the food protein, which broke down in the rumen.

A high concentration of urea in the milk results from a too high concentration of protein in the ration and at that concentration, the energy provided is insufficient to do all that required. (In fact, this is a waste of protein, together with an increase in heat load on the cow, which must invest energy in the effort to remove surplus protein.)

A low concentration of urea in the milk is an excellent indication of a lack of food, due to a drop in consumption or merely a lack of protein.

During the hot summer days, when insufficient heat stress relief is provided or the cooling method is inefficient, there is a rise in respiration rate, food consumption drops and with it the supply of energy. Consequentially, urea levels rise in the bloodstream and the milk. This is
perhaps a circumstance, which can be explained by a drop in food consumption that is even higher than the drop in milk production and the observation of a strange phenomenon – an improvement in the efficient exploitation of food to manufacture milk, at the expense of the cow’s condition and fertility.

The optimal range for urea in the milk is $7mg - 8mg / deciliter$ to $16mg - 17mg / deciliter$. Whereas we have insufficient information to analyze intermediate situations, this is an indicator, which can be used to learn a great deal about nutritional efficiency.

Urea in the milk is another in the range of tools at our disposal. If we make the wise choice and examine all of them together, we will be able to develop control methods and reach conclusions in time. If we have a great deal of patience, our work will bear fruit.

The enormous importance of microbial protein*, lies in the fact that it is a natural source of protein in the ruminant ration, both in terms of its composition and its complete match with the composition of animal body tissues and milk. Solely for the purposes of illustration, we shall examine the levels of two vital amino acids – lysine and methionine and their presence in microbial protein and milk.

Table 1: The Percentage of Essential Amino Acids in Milk and Microorganisms

<table>
<thead>
<tr>
<th>Source / Amino Acid</th>
<th>Lysine</th>
<th>Methionine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>8.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Microorganisms*</td>
<td>9.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

* A small proportion of the microbial protein – the DNA protein, is not digested

No similar ratio between vital amino acids and food and milk exists in any type of forage. Therefore, it would seem for the nutritionist to always work hard to create the conditions in which there will be an increase in the production of microbial protein. A management regime that strives to reach high milk yields does not provide enough microbial protein in the rumen to provide all the host’s needs. Under such conditions and to make up the lack, the widest possible range of proteins, which can survive the rumen, must be added to the ration. Researchers, different models and commercial companies are attempting to deal with the limited supply of vital amino acids, by protecting those amino acids before they are delivered as a food additive.

As illustrated in the table given above, the recommendation is to reach concentrations of 6.8% Lysine and 2.2% Methionine in the total of metabolic protein. Notwithstanding the natural limitations, I believe that the correct and most efficient way to reach that objective is to learn
how to nurture and pamper the microorganisms in the rumen. (Evadable energy and large verity of ingredient given in the diet may overcome such problem)

The discussion of protein must include byproducts. For example, gluten feed is a byproduct during the extraction of starch from maize seeds. Gluten contains a relatively high proportion of crude protein, some 40% of which is soluble protein, but even so, it makes relatively little contribution to the manufacture of microbial protein. In contrast, another, often slightly more expensive material, such as canola cake, contains relatively high levels of survive protein. Given that we have no efficient tools to measure the degradation and solubility of the various proteins, we must use the published data from previous experiments in laboratories around the world. Those experiments provide a picture, which is usually correct for the individual experiment and the conditions under which it was conducted. In the case of food industry wastes, the data will be accurate for the specific conditions at the manufacturing plant. On the commercial farm and in the differing conditions of ration composition, climate, etc, there might be different results and therefore, the wise choice is to learn and understand the principle and to be wary of precise numbers.

The following table provides examples of protein content in a number of different foodstuffs, in accordance with their levels of degradability and solubility. Close perusal of the table reveals that they are divided into two levels. One is degradable, escape protein. The other is the bound, soluble protein expressed as a percentage of the overall protein. Barley grain provides a good example: Crude protein: 11.3%, which is divided up into 79% degradable protein and 21% escape protein. 35% soluble protein is 44% of the degradable protein. 2% of the bound protein is 9.5% of the escape protein.
Table 2: Levels and Nature of Degradable and Escape Protein in a Number of Foods

<table>
<thead>
<tr>
<th>Food</th>
<th>% Protein</th>
<th>Soluble</th>
<th>Degradable</th>
<th>Escape</th>
<th>Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>11.3</td>
<td>35</td>
<td>79</td>
<td>21</td>
<td>2.0</td>
</tr>
<tr>
<td>Maize</td>
<td>10.0</td>
<td>12</td>
<td>35</td>
<td>65</td>
<td>6.2</td>
</tr>
<tr>
<td>Wheat</td>
<td>14.6</td>
<td>23</td>
<td>80</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td>Citrus peels</td>
<td>6.7</td>
<td>12</td>
<td>30</td>
<td>70</td>
<td>6.2</td>
</tr>
<tr>
<td>Gluten feed</td>
<td>21.7</td>
<td>48</td>
<td>70</td>
<td>30</td>
<td>2.6</td>
</tr>
<tr>
<td>Cotton seed</td>
<td>24.0</td>
<td>33</td>
<td>55</td>
<td>45</td>
<td>10.0</td>
</tr>
<tr>
<td>Canola cake</td>
<td>40.0</td>
<td>28</td>
<td>77</td>
<td>23</td>
<td>2.5</td>
</tr>
<tr>
<td>Soya cake</td>
<td>49.0</td>
<td>20</td>
<td>72</td>
<td>28</td>
<td>2.0</td>
</tr>
<tr>
<td>Urea</td>
<td>281.0</td>
<td>100</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Roasted soya seeds</td>
<td>41.0</td>
<td>16</td>
<td>51</td>
<td>49</td>
<td>4.0</td>
</tr>
<tr>
<td>Alfalfa forage</td>
<td>20.0</td>
<td>20</td>
<td>72</td>
<td>28</td>
<td>5.0</td>
</tr>
<tr>
<td>Wheat forage (green)</td>
<td>12.0</td>
<td>20</td>
<td>63</td>
<td>37</td>
<td>5.0</td>
</tr>
<tr>
<td>Wheat silage</td>
<td>12.0</td>
<td>40</td>
<td>70</td>
<td>30</td>
<td>10.0</td>
</tr>
<tr>
<td>Maize silage</td>
<td>8.5</td>
<td>50</td>
<td>73</td>
<td>27</td>
<td>4.0</td>
</tr>
<tr>
<td>Molasses</td>
<td>4.1</td>
<td>100</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gluten Meal</td>
<td>68.9</td>
<td>4.0</td>
<td>45</td>
<td>55</td>
<td>5.0</td>
</tr>
<tr>
<td>Whey</td>
<td>17.7</td>
<td>80</td>
<td>90</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>DDG</td>
<td>27.8</td>
<td>15</td>
<td>38</td>
<td>62</td>
<td>15.0</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>18.0</td>
<td>40</td>
<td>80</td>
<td>20</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Examination of the table illustrates the differences between the foods in terms of their degradability and solubility in the rumen. To this we must add the small amount of knowledge...
about the different foods’ varying contribution to amino acids and vitally, the importance of the degradable and soluble protein in the production of microbial protein which is the basis for the statement made above – There are no good or bad proteins; therefore, proper, cautious balance is the recipe that is best and most worthwhile adopting.

A higher level microbial protein in the rumen will more than anything else, ensure production efficiency and livestock health. Food protein is an important but not the sole factor in achieving that aim. The entire nutrition base for food consumption, energy balance for microbial activities, the quality and quantity of roughage and anything else that will support proper rumen functioning must also be taken into account.

Wise nutritionists know how to relate to all those factors and will not rely on the simple measurement of overall protein.
Productive Energy

In nature, the essential food groups store energy. That energy is released when the substance breaks down; the calorimeter is the standard instrument for measuring that energy. The calorimeter measures the number of calories released with the decomposition of a material and the figure it records is the total energy stored in the material.

The calorie is defined as the amount of heat released by the decomposition of one gram of the material. The scientific definition of a calorie is:

“The unit of heat equal to the amount of heat required to raise the temperature of 1 gram of water by 1°C at 1 atmosphere pressure at sea level”.

The value received and measured in degrees Celsius is therefore gram calorie or the “small calorie”. Burning one kilogram of the same material will give a value of 1,000 calories, which is a kilocalorie or “large calorie”. In real life, we calculate the calorific (energy) value of a material in mega calories (Mcal), which is the term used for 1,000 kilocalories and/or “ton calorie”.

The non-metric equivalent is measured in BTU (British Thermal Units) and Fahrenheit degrees.

Over recent years and principally in Europe, the measuring unit has been changed to the joule. The conversion coefficient from the joule to the calorie and the mega calorie to the mega joule is 4.184 (number of calories X 4.184 = number of joules).

In terms of nutrition, there can be no full exploitation of the energy stored in the material and therefore, to reach the calorific value achieved through the digestion process, we must deduct the energy lost in the feces (on average, some 30%) from the Gross energy (GE), which will give us the DE (Digestible Energy). After also subtracting the losses through urine and released gases (some 10% of the overall energy), we reach another figure, which gives us a reasonable measurement of Digestible Energy – ME (Metabolic Energy). Animal behavior and the various productions aim for milk, meat, body maintenance, etc., influence metabolic energy efficiency and therefore, we measure a different level of net energy for production (NE) in each segment in the energy utilization process.

Given that fat in the food plays no part in the different fermentation processes, some researchers and committees prefer to assess forage in terms of FME (Fermentable metabolic Energy), which is the metabolic energy not from a fatty source.

The accepted measuring unit for dairy farming is NE₉ (Net Energy for Milk) because it has been found that the metabolic energy is transformed into net energy for milk production with an efficiency of 64%, while the transformation into body maintenance energy has an efficiency of 62%. That difference is negligible for practical work on the farm.
To calculate a food’s NE₄ (Net Energy for Milk), we must conduct experiments with animals. Given that it is difficult to conduct a specific experiment for each food and combination of foods, we must use the knowledge gained through a scientific studies and then adjust the specific value for each food in the prediction formulae based principally on digestion experiments. The aggregated calculation comprising the data for each of the digested foods is expressed as TDN (Total Digestible Nutrients). The problem with the known TDN value is that it does not always follow the digestion experiment results and very often, the food value is calculated according to its chemical composition, based on prior knowledge stating that the release of digested energy during the breakdown of one gram of Fat provides 9 Kcal. Carbohydrates provide 4 Kcal, without any differences between sugar, starch or cellulose in terms of calorimetric values. Protein is a more complex issue, because as mentioned earlier, some of the protein does not break down completely. The accepted norm is to assume a loss of 1.25 Kcal for each gram of protein breakdown and therefore, despite the fact that protein has a calorimeter value of 5.64 Kcal, protein is calculated using 4 Kcal, which is the value determined after subtraction of the digestion losses and the urea.

Animals are dynamic beings. Looking once again at the analogy with the car, which has lower fuel efficiency over distance as speed rises, the same is true for animals. The authors of the 1989 NRC report calculated the drop in production value of feed at 4% for each multiplication of the quantity of energy consumed by the animal, beyond that needed for body maintenance. On average, the published tables give the food value for maintenance, less 8%, which is the factor that tries to take into account the average milking cow’s food consumption, if it is assumed that most cows on a modern farm consume the quantity of food that is three times body maintenance needs (body maintenance + twice times maintenance for production).

In 2001, the NRC committee estimated that the calculated results are higher than in real life and therefore, the committee suggested a correction factor: A reduction of 7% in the TND value in the calculation of the energy value for the food required for maintenance. A further reduction of 18% for producing cattle was applied to each additional multiplication of the quantity of food required for maintenance. To illustrate this point further – Accepted opinion assumes that high yielding cows require food quantities reaching up to 3 or 4 times the quantities they need for body maintenance.

As already mentioned, the physical structure of food has an influence on digestibility level. The 2001 NRC committee offers a table of food value corrections in accordance with food structure, set out as follows:
Digestibility Corrections According to the Physical Structure of Foods – PAF (Processing Adjustment Figure) The PAF correction applies only to decomposable and soluble carbohydrates, lacking a stable structure, such as sugar and starches (NSC = Non-Structural Carbohydrates), because their digestibility in most foods are in the range 90% - 98%.

Table 3: Food Digestion Corrections According to Foods’ Physical Structures (PAF)

<table>
<thead>
<tr>
<th>Food</th>
<th>PAF</th>
<th>Food</th>
<th>PAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled barley</td>
<td>1.04</td>
<td>Bread</td>
<td>1.04</td>
</tr>
<tr>
<td>Cracked maize grain</td>
<td>0.95</td>
<td>Ground maize grain</td>
<td>1.00</td>
</tr>
<tr>
<td>Steam flaked maize grain</td>
<td>1.04</td>
<td>Dry rolled sorghum</td>
<td>0.92</td>
</tr>
<tr>
<td>Steam flaked sorghum grain</td>
<td>0.92</td>
<td>Rolled wheat and barley</td>
<td>1.04</td>
</tr>
<tr>
<td>Normal maize silage</td>
<td>0.94</td>
<td>Mature maize silage</td>
<td>0.87</td>
</tr>
<tr>
<td>Molasses</td>
<td>1.04</td>
<td>All other feeds</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The table lacks vital corrections for other foods. It is unreasonable not to provide a correction for the value of whole straw, compared with crushed, chopped straw. The same applies to forage, silage, etc. Another practical correction always applied at the farm level is the checking of overall fiber length for the food mix (TMR), which is a function of the type of foods in the ration, the ratios in which they appear and the combined physical structure of the entire ration, which is very often influenced by the quality and the manner in which the food preparation and delivery machinery is operated.

In view of the high digestibility of food fats, loss of food fat digestibility is not usually calculated for a ration containing less than 3% fat. Furthermore, low value rations, with a TDN of up to 60%, are not eaten in large quantities by the cattle and therefore, such rations have no digestibility corrections for the rise in consumption, which as explained, is almost non-existent in practice.
Because it is impossible to have accurate energy estimation for every circumstance and on the
day to day basis, lacking sufficient measuring tools, we must rely solely on estimates. The
authors of 2001 NRC report claim that when the ration is mixed as a single deliverable feed – as
a TMR, there is no point in calculating for each foodstuff, a different digestibility for the rise in
food consumption.

A different approach, proffered in the book by P. Van Soest (1994), which determines that it is
unreasonable to ignore the individual properties of each foodstuff.

For example: A number of values for reduction of the TDN values applicable to each rise in the
level of body maintenance requirements as proposed by P. Van Soest:

Soy cake: 5.1%; Gluten feed: 13.5%; Crushed maize grain: 3.3%;

Cracked maize grain: 5.0%; Molasses: 0.0%; Wheat bran: 9.0%; Wheat straw: 11.6%.

If they are correct, all these values provide the farmer with production energy values different
from those presented in the NRC tables. Moreover, the values suggested by the NRC committees
are considerably different from the values suggested by the various European committees. The
farmer has a difficult time negotiating this maze. The authors of the NRC, the Cornell and other
reports do not provide the farmer with specific energy values in the model. The production value
for the entire ration is calculated by the model only after a mathematical examination of the
entire ration, its composition and the prediction of the quantity consumed. Both researchers and
nutritionists working in the field planning rations must have the tools enabling them to work with
individual values for each food. Researchers and nutritionists, who want to double check their
work, insert the planned ration into the model and examine the prediction it provides. The
farmer’s job is pay attention, criticize, to “talk” to it and then correct that which the model and
the nutritionists do not know how to predict.

To help examine this issue, the following table gives values for a number of foods as proposed
by three different American sources (values are given in Mega calories per kilogram dry matter,
calculated for three maintenance multiples).
Table 4: Comparison of Net Energy Values from Different Sources

<table>
<thead>
<tr>
<th>Food</th>
<th>NRC 01</th>
<th>NRC 89</th>
<th>Van Soest 94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa forage</td>
<td>1.28</td>
<td>1.30</td>
<td>1.23</td>
</tr>
<tr>
<td>Barley</td>
<td>1.86</td>
<td>1.94</td>
<td>1.92</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.99</td>
<td>2.04</td>
<td>1.98</td>
</tr>
<tr>
<td>Maize</td>
<td>2.01</td>
<td>1.96</td>
<td>2.04</td>
</tr>
<tr>
<td>Cotton seeds</td>
<td>1.94</td>
<td>2.23</td>
<td>2.03</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>0.76</td>
<td>0.96</td>
<td>0.78</td>
</tr>
<tr>
<td>Gluten flour 60/5</td>
<td>2.38</td>
<td>2.06</td>
<td>2.06</td>
</tr>
<tr>
<td>Gluten feed</td>
<td>1.73</td>
<td>1.91</td>
<td>1.49</td>
</tr>
<tr>
<td>Canola cake</td>
<td>1.76</td>
<td>1.60</td>
<td>1.33</td>
</tr>
<tr>
<td>Soy cake</td>
<td>2.14</td>
<td>1.94</td>
<td>1.78</td>
</tr>
<tr>
<td>Sunflower cake</td>
<td>1.38</td>
<td>1.47</td>
<td>1.27</td>
</tr>
<tr>
<td>Beet molasses</td>
<td>1.84</td>
<td>1.72</td>
<td>1.70</td>
</tr>
</tbody>
</table>

One of the key statements I found in the excellent book authored by P. Van Soest, states the following:

“The digestibility estimate is the single largest error in most systems....”

We understand from these comments that the tools at our disposal for the estimation of productive energy are inadequate and therefore, it is the nutritionist’s task to know and often adjust the values to the realities. The nutritionist must constantly check and amend.

In many areas in Northern Europe, nutrition management is based on pasture, which is high in degradable and soluble protein, and degradable fiber, with high digestibility. In view of that level of digestibility, nutritionists attribute relatively high energy values to such grass. Because the level of digestibility has a not-to-be-dismissed artificial digestibility component; such a diet may leave the animals with a lack of energy. Over recent years, the ever increasing use of maize...
silage in those countries has improved ration balance, because it is food that is harder to break down, which provides more actual energy and consequently, higher yields.

Examining two standard roughage foods as found them in a report from the central laboratory in the North West USA (Dairy 1).

**Table 5: Comparison between Two Types of Hay (values as a % of the dry matter)**

<table>
<thead>
<tr>
<th>Food</th>
<th>Protein</th>
<th>Soluble Protein*</th>
<th>ADF</th>
<th>NDF</th>
<th>NSC</th>
<th>Fat</th>
<th>Ash</th>
<th>TDN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Hay</td>
<td>4. 9%</td>
<td>1. 9%</td>
<td>5. 9%</td>
<td>149</td>
<td>.91</td>
<td>.94</td>
<td>.94</td>
<td>459B</td>
</tr>
<tr>
<td>Oat Hay</td>
<td>.94</td>
<td>5. 9%</td>
<td>549</td>
<td>3. 9%</td>
<td>.4 5%</td>
<td>.9..</td>
<td>.9.4</td>
<td>459B</td>
</tr>
</tbody>
</table>

* Values calculated as a percentage of the crude protein in the food.

The most interesting conclusion from this example is that despite the significant differences in botanic nature between the two types of hay tested and despite the significant chemical differences between the two foods, the suggestion made to the user is that their calculated energetic value (TDN) is almost identical.

**Animal Needs**

Animals’ needs include the entire range of foods and sources of energy. However, the total need depends upon a very large number of variables and those needs are different according to the animal’s size, age, the production objective – milk, meat, racing, wool, etc. and the different physiological situations such as calf growth, more meat on fattening calves, the various components of milk, getting pregnant, pregnancy, etc.

Any number of committees has and will continue to produce tables based on the various animal needs according to the objectives mentioned above and therefore it is not appropriate to present here, all the vast and easily accessible databases. However, almost no data exists on the optimal nutrition levels for those animals, which we keep in non-homogeneous groups and even less data is accessible in the field in real time – that very data which would help us calculate how to provide the individual cow with all her needs, when that cow is simultaneously in the early stages of pregnancy and undergoing changes in weight and condition. In the real world, we do not always know the cow’s weight, how much she is eating on any given day, etc. The solution is based on knowledge of rumen functioning, the dominant trends in a given group of animals and on the core factors influencing food consumption. Together, they are used to plan balanced nutrition for the group in which all the animals will be able to eat according to their needs and will produce to their maximum. In practice, we examine each animal individually according to its abilities and sometimes, we will remove an animal from the herd, because it does not react to our satisfaction. Animals on a working farm are not pets and the main reason for keeping those animals is to produce the maximum for human beings.
Many companies and researchers have not yet given up the search. They are using the most advanced electronic technologies available to develop accurate tools for individual feeding. These tools are not yet sufficiently accurate and most, perhaps with the exception of a small number of research laboratories, only provide the per cow quantity of concentrates in the ration. The fact is that there are very substantial differences between the different animals; we discover that with the exception of a small number of farms, we must continue to develop group management methods. Such groups must be as homogeneous as possible and that is even truer as individual dairy farms and production units grow in size. It would seem that the rule applied here is that we must continue to examine and balance ration ingredients and the range of ration using knowledge and experience, while at the same time, the cow will eat that ration to the best of its abilities and shall be judged simply on its performance.

The various committees (Cornell, NRC and others) translate cow and all other farm animals’ needs into numbers. They present the numbers in tables and today without details such as body maintenance, milk, weight gain, etc. Without exception, the various committees discuss the individual animal and the physiological stage it has reached. It is almost impossible to find orderly recommendations and research dealing with the herd’s needs, even though cattle and all other ruminants grown on the farm consume their food in groups.
The Links between Feed Consumption and the Nutrition Program

Feed consumption is the measure that expresses the work on the farm and the cow’s production potential during the next lactation. Feed consumption is a function of the cow’s body condition and genetic makeup. The animal’s need for energy, protein, minerals and all the other components of nutrition will not be met if the food is not eaten. Overeating – if it actually exists, will result in the diversion of food into the body and the animal will fatten up. Given that fattening can also occur at low nutrition levels, after changing the ration, changing the food, etc., overeating – if it exists – is a relative value in any given situation and not an absolute value. Whereas ration balancing takes the cow’s needs into consideration, various other factors influencing consumption determine the efficiency level for each of the various nutrition factors. Food consumption is the benchmark management uses to calibrate the gap between the cow’s needs and the various nutritional factors.

In the previous chapter, we touched upon the various factors, which constitute a reflection of the food, the management system and all the other conditions expressed as cow performance and used by researchers to predict food intake. Food benchmarks in standard models and to a great extent in real life are taken into account in the form of the recommendation to balance the ration in terms of cell wall and maintaining a ratio of 75% of the total cell wall as roughage. The principal importance of NDF when planning a ration lies in its contribution to monitoring rumen fill level and food intake.

The first factor of great importance is the cell wall. It has been found that up to a level of about 30% cell wall in the total dry matter in the ration has little influence on dry matter intake (because the ration volume is relatively small, compared with rumen volume). When the ration contains higher levels of cell wall, a very steep drop in dry matter intake is often observed and cannot be ignored. Any discussion of cell wall must inevitably lead to a discussion of cell wall source and quality. Wheat straw cell wall is not similar to the cell wall in young alfalfa, or bran, which is different from maize grain and so on and so forth.

In the typical Israeli ration, cell wall from roughage comprises only some 50% of the total cell wall in the ration, because forage quality is a function of the climatic conditions in that part of the world.

The commonly given advice is to predict dry matter intake according to cow performance; a drop in roughage quality, together with a different cell wall ratio between the roughage and concentrate components does not permit us to manage without this important nutritional benchmark. Moreover, the composition of milk can change under the influence of anti-acid additives, (caustic soda treated seeds, etc.).

Cell wall and the ratio between cell wall from different sources might have different results, particularly when considering the effects of a food’s physical structure. Coarse chopping will
encourage consumption, when compared with food not chopped at all. When the food is chopped too finely, it will sink rapidly to the bottom of the rumen, cud regurgitation rate will drop, it will cause acidosis (a rise in the level of rumen acidity) and consumption will be affected.

Moisture level in the ration is another very important factor. Adding water to dry food such as straw, hay and concentrates, prevents dust and if the ration is balanced within the range of 50% - 60% dry matter, it is reasonable to assume that the addition of water will have a positive effect on dry matter intake. In contrast, “wet” foods, to which no additional water has been added and their moisture is contained within the plant cells, such as in the case of silage with low dry weight of 28% - 30%, or if the ration contains a high percentage of citrus peels, etc, will lead to a drop in dry matter intake. The effects are not linear. When silage is too wet, there is a drop in dry matter intake and yield, while at the same time, even though a reasonable proportion of citrus peels might reduce dry matter intake, it can also make a positive contribution by improving digestibility. Therefore, the situation might arise in which lower dry matter intake has on effect on production level and can even result in a higher yield.

A small digestion experiment was conducted which compared two identical rations, but in one of the rations, the silage component was replaced by hay made from the same plant as the silage and that hay was harvested at the same stage as the silage. The hay ration was better eaten, while the silage ration was digested better and the total amount of energy available to the animals was the same. We added tap water to the hay ration to reach the same moisture level as the silage ration and consequently, dry matter intake in the “dry” hay group was the same, but digestibility and yield were lower. Apparently, adding water was detrimental because it caused early fermentation.

Time from calving is another factor with an influence on consumption (dry matter intake drops as the lactation progresses) and a rise in body condition score will cause a drop in dry matter intake (when two cows have identical weight, the cow in better condition score will consume less food).

Dry matter intake is the best on-the-farm tool for the characterization of the link between production, the ration and management system.

When ration composition and management are at reasonable levels, the best way to monitor the link between dry matter intake and production is by constantly monitoring the efficient use of food. Examination of the NRC and other models, together with accumulated local experience, shows that on average; normal dry matter intake is about 0.7kg dry weight eaten for every 1.0kg of milk produced (the reasonable range varies from 0.65kg to 0.75kg). On high yield dairy farms, values range as low as 0.58kg dry matter intake / kg milk produced to 0.85kg – 0.95kg; the latter value in places where the ration was not balanced and/or the cows were at advanced stages in their lactations. A number of countries calculate this norm differently. They divide the quantity of milk produced by the dry matter intake and the resulting figures are in the range 1.35 – 1.55.
Constant monitoring of this measurement constitutes an important supplementary tool, used to analyze the results and ration composition from the economic and nutrition management aspects. It is important to take into account the fact that environmental factors also have an effect on the efficient use of food. The greater the time calving, the more food efficiency falls. In summer, food efficiency rises because the detrimental effect on dry matter intake in a hot climate is greater than the effect on milk production. Contrastingly, in winter, more of the consumed energy is diverted towards body maintenance needs and food efficiency measured as production, is lower. Disease, living conditions and most importantly, an ill balanced ration containing high fiber forage with low digestibility are all important factors in terms of their influence on the efficient use of food and dairy farm economics.

The most important factor is dry matter intake. The quantity of food consumed in order to produce a liter of milk can have greater economic consequences than the price of the food.
Fiber Foods (Roughage)

Fiber rich foods are vital to ruminant nutrition. We have already touched upon the importance of the process through which the rumen is filled, the cud regurgitated and the digestive system functions. On most farms around the world, there is little trading in fiber foods, but technological developments, the competition for land and water and the growth of dairying unit size have resulted in a new model for the farm, in which all foods for the dairy farm, including the food grown beyond the farm fence, are examined by a complex array of tests, to determine their value and potential economic contribution. The cost analysis applied uses the market price for alternatives as the yardstick for comparison.

The following table gives a sample range of the principal fiber contributing foods; their chemical composition and their resulting range of properties, which determine the level to which they will be included in the overall ration. Looking at this table, we can discern the essential differences between legumes and cereals. Legumes contain more protein, but have only a medium level of fiber digestibility. Cereals contribute less protein to the ration, but have more, better digestible fiber. It is also possible to discern the differences between wheat, which grows mainly during the winter months and maize and sorghum, which grow during the summer.

The farmer must take into account these diverse properties and the different contribution made by each type of food. The farmer should balance the ration at 40% - 50% roughage dry matter when the food is comprised of maize silage and alfalfa hay (or fermented alfalfa hay). When wheat silage and wheat hay are available, it is possible and often necessary to balance a ration with just 30% roughage.

Therefore, when planning the constituent parts of the ration and particularly, when that ration is delivered as a TMR, every farm and every nutritionist must be well aware of the special properties of each available food.

Our guiding principle is that when high quality NDF food is available, we must reduce the proportion of grains in the ration and vice versa – when the fiber food has less energy and more cell wall. In other words: The lower the roughage coefficient in the ration, it must contain a higher proportion of roughage and therefore, grain content will drop. In the opposite case, the higher the coefficient of roughage in the ration, it will not be possible to include higher levels of roughage and it will be necessary to find alternative sources of energy, such as grains and/or high energy supplementary materials.
### Table 6: Comparison of the Content, Digestibility and the Roughage Coefficient for Different Foods

<table>
<thead>
<tr>
<th>Food Properties</th>
<th>Legume Hay</th>
<th>Cereal Hay</th>
<th>Straw</th>
<th>Wheat Silage</th>
<th>Maize Silage</th>
<th>Sorghum Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Wall Digestibility</td>
<td>Medium</td>
<td>Good</td>
<td>Low</td>
<td>Good</td>
<td>Good</td>
<td>Medium</td>
</tr>
<tr>
<td>Roughage Coefficient</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
<td>High level dependent upon chop length</td>
<td>Low level dependent upon chop length</td>
<td>High</td>
</tr>
<tr>
<td>Protein</td>
<td>4. -41 . -</td>
<td>. -</td>
<td>. 4. -</td>
<td>. -4</td>
<td>. -3</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Acidity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

When comparing silages to hay, it is important to remember that when making silage, almost all the leaves reach the silage pit. Which is why silage has such a high energy value. In contrast, the very fact that the silage is acidified raises the rate at which the food breaks down in the rumen and that is a fact common to all foods with high cell moisture.

The level of dry matter in the hay changes slightly between the time it is baled and when it is fed to the animals several months later. It is also true that a loss of leaves is to be expected and that means that when the hay is fed, it will have lower nutritional value that at harvesting.
Realities on the Farm Affecting Food Consumption

It is difficult to maintain a fixed level of dry matter when preparing silage. On most farms, silage cutting continues over a number of days from a number of fields. Each field is cut at a different time of day and as appropriate to the climatic conditions during harvesting. Changes in the time available for wilting have very large effects on the percentage of dry matter in the vegetation loaded into the silage pit and later on, delivered to the trough.

To feed the silage, we must cut the material out of the pit cross section, going from top to bottom of the silage pit face. The material at the bottom of the pit is usually different from the material at the top, if only because the materials were not cut and ensiled at the same time, or even on the same day, field or plant variety. On rainy winter days, another factor influences the silage.

A computer is used to plan the ration after averaging the laboratory tests on the various raw materials. As mentioned above, there are often very considerable differences between materials, but the differences in water content between silages is far greater than the differences found in dry foods.

Cows eat what they are fed without regard to the quality of the food which may have been compromised by moisture.

A telephone call and a typical complaint – “They aren’t eating”. There are many possible reasons why this happens – extreme climatic changes and/or changes in the cow population in the herd after a large number of cows are dried off, multiple simultaneous calving – all can lead to changes in food consumption at the herd level. On the other hand, it often happens that the silage delivered that day was drier / wetter than the figure reached by laboratory testing and used when planning the ration. It is also possible that knives had broken in the mixer wagon and the materials were not mixed and chopped as planned. Sometimes without noticing, the operator can change mixing times and degree and more…

An adage amongst nutritionists is that there are any number of rations - the planned ration, the ration loaded into the wagon, the ration mixed too long and the ration chopped too short. Of course we must not forget that there is also the ration delivered to the cattle. The feeding machinery currently available to us is insufficiently accurate and the mixture delivered to one end of the trough is not the same as that delivered to the other end. After all this long process, the similarity between the ration eaten and the planned ration can still be entirely coincidental.

A description of a feeding problem, solved:

Visiting a farm, I discovered something very strange. Some of the cows consistently gave less milk with more solids than the other cows in the herd. Closer investigation revealed two important points. One was that the mixture at the beginning of the trailer was different from the
mixture at the end, but the really interesting reason for this strange phenomenon was that even when free fed, the cows always ate from the same side of the trough. Problem solved.

The real lies in the constant monitoring of dry matter intake, along with an institutionalized, routine, check on dry matter levels in silage and an appropriate, daily adjustment of silage level in the ration.

An even simpler tool is the laboratory oven, which should be on hand at every feed center. The oven designated for the testing of silages must be calibrated to operate at 65°C and the sample of material must be in the oven for 48 hours. The difference in weight between the fresh sample and the dry sample, will give us the percentage of dry matter, which we will use to calculate the quantity required for nutrition. A routine repetition of this test two to three times a week will allow calibration of the rations and will be a positive contribution to nutrition management.
Maize (Corn) as a Food for Ruminants

Maize is the main forage plant in many countries around the world. For many years (in the U.S.A.), maize is grown in more than half of the available, growing area. Maize is also popular in eastern and southern Europe. In recent years, maize has penetrated into many more countries, including northwest Europe.

In Israel, maize is the main summer forage plant. In Israel and many other countries, maize is under pressure from sorghum, because of the need to maximize the exploitation of the limited volume of water available for agriculture.

In most forage plants, dry matter digestibility drops as the plant matures. Digestibility drops very little in maize. Dry matter digestibility for maize, when the whole plant is used as forage, ranges between 68% - 72%. It reaches its maximum when harvested at the “soft dough” stage. A number of chemical tests have been used to compare maize harvested with only a few or many cobs have found very little difference in cell wall content, compared with the entire plant (51% compared with 53%). Because of the quantity of seeds, estimates of the total net contribution of energy for the different maize plants at between 1.5 and 1.6 mega calories / kg dry matter. (NRC 89)

Different maize varieties comprise 40% to 60% cob and seeds. Thus, in contrast with other forage plants fed green and/or as silage, maize is more frequently defined as a “complete diet” food rather than as roughage, like most green plants. In order to achieve the effect of roughage when using maize, harvesting technologies must be developed with the ability to crush the seeds and mash the cobs to the greatest possible extent. Discretion must be used when dealing with the vegetative parts of the maize plant as appropriate to the other components in the ration and the position held by maize silage in that ration. A regime that lacks fiber will require us to harvest with a seed crimper, while the leaves and stalks will be a relatively long chop. The opposite will be true when maize silage is the principal food. The whole plant will be chopped to an average length of 0.5cm, to ensure the efficient use of the food and its digestibility.

Maize is used by farm animals in an endless variety of ways. Fresh green fodder, maize silage with more or less seeds, sweet maize stalk silage using the field remnants after the cobs have been picked for human consumption; the cobs after removal of the seeds by the sweet corn industry, whole cobs, seeds after different types of treatment and many different types of byproducts from the starch and alcohol industries use maize seeds as a base material. Each of these different materials has its own use. Notwithstanding the fact that they come from a common source, each of these products has its own properties and place in the ration.

As roughage, maize silage rich in cobs is an important ration component. Commonly, this type of silage contains some 33% - 36% dry matter, about 8% protein and it has 50% NDF, 4% - 5% lignin, 4% - 6% ash and a calculated net energy value of 1.5 – 1.55 mega calories / kg dry matter.
If maize silage is the only and/or the most important roughage provided in the ration for a dairy cow, it must be given in quantities ensuring that the total amount of cell wall from non-roughage sources in the ration is no lower or even higher than some 20% - 21% of the total dry matter. The same is true and possibly even more critically important, when including seedless cobs in the ration.

“Maize” is a catchall term. Breeders are changing maize varieties and other plants on an almost daily basis. When a maize variety designated for seed growing, which for economic or other reasons, is transferred to silage making, there is good reason to suspect that it will have a high moisture, watery stalk, even when the seeds are already hard and dry. In such circumstances, all decisions on harvesting date will be wrong. Early harvesting will produce silage that is too wet and harvesting according to seed growth stage will mean that the foragers available to us will not be able to provide the goods. The maize seeds will remain whole in the silage and in that condition, they are indigestible.

Industrious farmers, mostly in the warmer areas with little rainfall, can successfully grow three different crops on a field over a twelve month period: Wheat for silage in the winter, maize in the spring and another short growing period crop in the autumn. Autumn maize is sown at high seed density; it does not produce cobs and it is used as supplementary roughage, mostly for calves. The problem with the autumn crop is that because it is harvested late, climate problems frequently arise during harvesting and therefore, its nutritional value is relatively low in the absence of seeds.

Other uses for maize as roughage include the use of the stalks after the grain has been harvested. The nutritional value of the stalks depends upon their source (cobs for the fresh market, sweet corn for processing or popcorn). Usually, sweet corn is more delicate and more nutritious, while seed corn and popcorn wastes are coarser; parts of stalks are not eaten at all and regrettably, they are often accompanied by too much soil.

Maize grain is a very important component in the concentrates fed to cattle in most countries around the world. Maize seeds have relatively low protein content (8% - 9%) and they are high in starch, which constitutes some 60% - 70% of the entire seed. Maize starch has a relatively stable structure and texture and therefore, its breakdown in the rumen is slower than other grains such as barley and wheat, which have a cardinal effect on the production of microbial protein and the volatile fatty acids created in the rumen, which constitute the cows’ main source of energy. Most of the digestion and absorption of maize starch into the body happens directly in the intestines. The slow breakdown of maize seed starch is detrimental in terms of its digestibility, which occurs at a rate lower than the breakdown rate for barley and wheat. Therefore, when feeding maize, it is normal to find more undigested starch in the feces than when feeding barley or wheat (sorghum has properties closer to those of maize than to the other grains). Direct absorption of starch in the intestines has many positive aspects, which are usually exploited during critical periods in the cow’s life (transition periods), during which that property sponsored by the Israeli dairy School.
of maize has a vital, positive effect on available energy to the host animal and the prevention of metabolic disease (ketosis). That same property is also a disadvantage in terms of rumen functioning because of a lack of energy available for the activities of microorganisms.

Thus, in no circumstance should maize seeds be provided as the sole grain in the ration.

Consideration must be given to its inclusion along with other grains. The properties and breakdown rate for maize seeds in the rumen are to a great extent, dependent upon how they were prepared before they are fed to the animals. Cracked maize is less digestible than ground maize. Rough ground maize seeds are less digestible than finely ground maize grains and that is clearly illustrated by the gap between the net energy value for cracked seeds published in NRC 89 – 1.84 mega calories compared with a value of 1.96 for finely crushed grain. Other treatments such as steam treatment raise the rate of maize seed breakdown in the rumen and steam is the recommended treatment in many US states, where maize is the only, or the principal grain fed to the cattle. When steam treatment is combined with rolling, its value rises (according to that same source – NRC 89) to about 2.04. In conditions where almost no ration does without barley and/or wheat or rye grain, steam treatment is not recommended and as already stated, that is in contrast with regimes in which maize is main or perhaps the only grain provided.

The food industry and of late, the energy industry as well, use maize for a variety of purposes, such as the extraction of oil, starch and fermentation of alcohol. After using the maize seeds for those purposes, the by-products of these different industries return to the farm; sometimes in the form of dry concentrates, which can be included in the concentrates mixture and sometimes as high moisture wastes for direct inclusion in the ration mixture.

Distillers’ dried maize grain (DDG) is the result after maize has been used to produce starch or alcohol. This material is often offered with and/or without various suspensions, such as seed dust, yeast, etc. The material includes distillers dried grains with soluble (DDGS) and it is not much different from the dry product, with a nutritional value very similar to it, with the exception (according to various sources) of its protein properties as escape protein, which is at a lower level in materials containing the soluble. The overall protein content in DDG reaches some 29% - 30% with about 7% - 8% free fats. Therefore it is a good idea not to use too much of this product when it is necessary to deal with milk protein problems. DDGS is produced by factories specializing in the production of starch, not alcohol. The properties of DDGS are different from those of DDG, mainly due to the fact that the processes are different and DDGS contains more cracked seed and less fat than DDG.

Gluten feed is a material similar to DDGS and gluten feed is also a byproduct from the starch industry. Protein and fat levels in gluten feed are lower than in DDGS: 25% - 26% protein and just 2% - 3% fat.

All DDG, DDGS and/or gluten feed products contain the outer covering of the maize seed (bran) and therefore, laboratory test results give relatively high values for cell wall content at about

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44% - 45%. Given that the materials is delivered ground and dry, it is impossible to attribute any great value to that cell wall constituent in terms of its contribution to ration volume and rumen functioning.

It is important to pay attention to the significant differences between these different products. Gluten feed contains high levels of degradable protein, most of which is soluble, while DDGS contains higher levels of escape protein, most of which is bound (ineffective escape protein not absorbed by the body).

Another product is 60% protein maize – gluten meal. This is a byproduct from the corn flour industry and its main ingredient is protein, along with some cell wall and small quantities of fat, similar to gluten feed. In view of the technology used to prepare gluten, it is common practice to value this material as rich in escape protein and its principal contribution is to the amino acid methionine. The obvious disadvantage is its lack of another vital amino acid – Lysine.

In some places around the world, with high maize yields and good climatic conditions, it is common practice to make silage using maize seed, both with and without the cobs. However, despite the considerable interest in these products, they not good solutions in warm, tropical climates.

In some countries, principally France, the cobs are gathered and dried in special facilities and in the fields, before grinding the dry cobs for their inclusion in the cattle ration.

In countries further north, such as Holland and Scandinavia, maize silage, which as mentioned, breaks down slowly, is included in a ration based mainly on grass, which breaks down rapidly. As has been discovered only relatively recently, the inclusion of maize contributes towards balancing the ration and considerable improvements in the results. Contrastingly, in the USA maize is combined with alfalfa, which therefore requires the addition of available energy to ensure proper rumen functioning. In those regions where maize grain constitutes the most important ingredient in concentrates, the results will be better after steam treatment. Steam is a very warmly recommended technology when the farm has no other source of degradable starch, such as that available in wheat and barley.

Grain screenings is another alternative product, which should also be examined and carefully considered. Grain screenings – the byproduct after screening and cleaning maize seed, includes seed particles and often also includes other seeds from foreign materials. If the seed has been in long term storage, it also contains spoiled and moldy particles of seed. Sometimes, when the product is fresh, it is just maize and if so, it is worthwhile using it, mainly for fattening calves. However, when the screenings are from stored materials and they contain foreign matter, they must be examined carefully. Professor McCullough from Georgia once described this product to me as a “good product, suitable for export”.

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As a rule, maize is a high energy food and the common denominators for all products created from a maize source (with the exception of high moisture products and/or steam treated products) is break down in the rumen and flow into the intestine, where it is absorbed. However, as the consequence to that process, in comparison to other foods, a high percentage of undigested starch is excreted in the feces.
**Wheat Silage**

Wheat silage is the main roughage component in the standard Israeli ration and other countries with similar climates. The objective when growing wheat for silage and when determining harvesting date, is to reach a high level of digestible fiber, without the loss of total dry weight harvested in the field.

To achieve that objective is to transform wheat, which is essentially not a forage plant, by sowing late maturing varieties unsuitable for the production of grain (as appropriate to the climate, rainfall and soil type) and to harvest at the stage when the plant has ended flowering and has begun to fill the seed. It has been found that late maturing varieties harvested at this stage provide no less dry matter, with a high level (perhaps even slightly higher) of digestible NDF per hectare, when compared to early maturing varieties, traditionally harvested at the end of the milky grain stage and the start of the grain dough stage.

Particular care must be exercised when ensiling wheat, to prevent anything going wrong during the material compaction stage. Fermentation must be controlled and rapid; otherwise, good reason exists to worry about the quality of the silage. Wheat for silage should be chopped to an average length of some 2.5cm which will ensure compaction quality as well as the roughage effect of the material. Plants cut before the grain fill stage contain some 30% dry matter or less and therefore, they require wilting (in accordance with climatic conditions) to about 33% - 34% dry matter. Whenever there are doubts about silage quality and to ensure a long shelf life after the pit is opened, it is very important to add the various silage preservation additives (both chemical and bacterial).

The crop sowing schedule will be planned to ensure that it will be possible to harvest (at least some of the wheat) without climatic limitations. That means sowing at least some of the area on a slope, on well-drained soil and/or light soils. In high rain areas and when only heavy soils are available, there is no need to rush and get the plants to sprout in the late autumn.

**Wheat Silage Quality Control Criteria:**

- Cell wall content in the dry matter reaches 56% - 60%*
- Total protein content in the dry matter reaches 9% - 11%
- Ash content in the dry matter reaches no more than 9%
- It is possible to estimate the additional nutritional value when cell wall content rises above 60%, when protein rises above 11.1% and the ash is less than 8.5% (nutritional value is about 10% higher)
- Silage containing 56% - 58% cell wall, 8% - 9% protein and 9% - 11% ash, shall be classified as Grade 2 (10% lower nutritional value), because it was harvested just a little too late and there will be more lignin as a percent of cell wall
• Silage containing 54% - 56% cell wall, 7% - 9% protein and more than 11% ash shall be classified as Grade 3 (nutritional value some 20% lower than standard).
• Silage containing less than 54% cell wall or less, 7% protein and more than 12% ash, shall be classified as Grade 4 because at this stage, lignin levels larger part of total NDF. In this situation, it is a good idea to hold a special discussion to decide if this silage can be included in a dairy cattle ration.

* Some laboratories, with a solely chemical viewpoint on these matters, are unable to classify the physiological stage at which the wheat was harvested, if they are not provided with the prior information they require from the supplier of the sample. The missing information might lead to the laboratory offering a misleading assessment. If there are identical levels of total carbohydrates in the plant the laboratory might estimate that wheat cut on different dates to be identical (when the value is translated into net energy units in nutrition tables). On more than one occasion, laboratory reports for wheat silage late mature (low cell wall values in physiologically mature plants high in lignin) show higher net energy values than for silage cut young (before grain fill with much higher levels of digestible cell wall). That happens despite the higher digestibility of cell wall in the young plant. Laboratory testing sometimes gives identical cell wall values for plants cut both before and after grain fill. With the beginning of grain fill, the plant transfers cellulose into the grain, into starch and all the properties of vegetative parts of the plant change significantly. When estimating the contribution of carbohydrates to productive energy, the user must pay particular attention to the source of the carbohydrates, which tend towards more starch as the plant ages and is the opposite in a young plant.

Preparing the Materials for Ensiling

• Effort must be made to ensure that the dry matter in the silage pit will be in the 32% - 34% range. Assuming that during harvesting, the material contains some 28% - 30% dry matter, ensure that wilting will take as short a time as possible in accordance with the wind and sun conditions and up to 24 hours when the skies are overcast and there is no wind.
• Do not transport the material to the pit at a rate that will overwhelm the ability to load and compact the material in the pit.
• The pit must be covered in a way that will leave no air pockets and the covering material must be tight against the ensiled material.
• Consider the addition of preservatives, which shorten fermentation time and can extend the shelf life (after the pit is opened) for the open clamp cross-section, the silage already mixed into the TMR. The preservatives may even contribute to an improvement in digestibility.
**Wheat (or Oats) as Forage Hay**

Wheat can be preserved as hay during those seasons when the weather permits enough time for the plants to dry. Wheat hay has advantages in terms of storage and its effects on drying the ration and in so doing, makes a small contribution towards dry matter intake. When there is a lack of fiber in the ration and/or when the main fiber in the ration is a legume and/or young grass, winter cereal hay such as wheat or even oats hay have an advantage in terms of balancing the ration for the purposes of cud regurgitation and rumen functioning.

In high stress growing conditions caused by soil type or a lack of water, it is reasonable to be cautious about the accumulation of nitrates, which can have an adverse effect on fertility, cause miscarriages and even death when their concentration in the ration rises above some 0.2%, or even less. Salts also accumulate in hay when there is stress during the growing period and excess salt can lead to edema, lower yields and negative effects on the cow, mainly around calving time. Silage is the preferred food for production under stress conditions because the fermentation process transforms nitrates into \( \text{N}_2\text{O} \) gas, which evaporates and therefore neutralizes any adverse effects.

A lack of care when preparing hay from annual plants such as winter wheat might result in the damaging inclusion of earth in the bales and particular attention must be paid to this problem.
Legumes (Properties and Importance in the Ration)

Author’s Note

some have called alfalfa “The queen of the forage”. My personal knowledge of this issue began as a young student under the tutelage of Professor Chaim Tagari. The work was conducted during a time when all the talk was still about the importance of digestible protein and it was unusual to say anything more than that on the topic. Professor Tagari was the first who made me understand that there is something in protein that cannot be measured just in terms of overall crude protein (N x 6.25) and digested protein. A series of experiments was conducted, placing emphasis on the comparison between different proteins and most importantly, legume (alfalfa, vetch, etc.); proteins were compared with soya proteins. As a precursor to this work, there was a comparison between soya proteins with and without heating and even then it was known that controlled heating had a positive effect on the efficiency of protein exploitation. The outstanding finding in this comparison work was that notwithstanding the fact that legume proteins break down rapidly in the rumen, there is no increase in urea levels in the blood and the opposite was true – there was a drop in blood urea levels accompanied by an increase in microbial activity in the rumen and the formation of microbial protein. It was discovered that the inclusion of legumes encourages the formation of microbial protein, and when fed together with heated soya (which increased the level of protein survival) it seemed that this was the best match in terms of protein for ruminants.

Growing alfalfa requires large amounts of water and therefore, the use of winter legumes became more widespread in low rainfall areas. However, even the very best farmers cannot produce legumes of the same quality as alfalfa because it rains during harvesting and there is more earth in the bales.

The search for ways to influence protein levels in milk, together with the understanding of how important it is to cow health to reduce the level of urea in the blood and the urine, once again lead to the focusing of attention on the possibilities and advantages, when including legumes in the ration in low rainfall areas.

In parallel with the efforts investigating protein in the milk, a range of research work on growing calves as replacements began to be published. The wish to maintain on the one hand, a free feeding regime and on the other, to prevent over fattening, lead to the creation of rations with ever growing percentages of protein and a reduction in the concentration of energy. Higher percentages of protein in the ration generated advances in the management of calves, which were soon taller, longer and thinner – but they also had fertility problems and severe foot problems, which were apparently caused by a relative lack of available energy, also expressed as a rise in blood urea levels. At that stage, we understood that legumes were the key to solving the problem of how to increase protein percentages in the ration without detrimental effects on fertility and bad feet; legumes would be easier for regulating protein quality (microbial protein) and the harmful levels of urea in the blood.
The best legume, which contains just 40% cell wall and much more than 19% protein, also had the most positive effects in the fattening sheds. Inclusion of legumes raised dry matter intake and as a result, body weight. Legumes also had a positive effect by raising food consumption during the difficult summer months.

It is difficult to ensile legumes because they are low in carbohydrates, but that also means that they have on farm and technological advantages during the rainy spring months. In all circumstances, it is important to remember that fermentation doubles protein solubility and the degree to which protein is bound to the lignin. Moreover, it is likely that fermentation will have an adverse effect on cud regurgitation processes and legumes’ role as roughage, which is another advantage of hay over silage.

In a situation where there is a lack of roughage, legumes have less importance because in those conditions, cereal hay has an advantage because it is higher in cell wall and particularly in digestible cell wall.

Spring alfalfa will always be better than summer or autumn alfalfa because of its leaf / stalk ratio. Delicate vetch, when it has not been baled in rainy conditions, is of no lower quality than most sources of alfalfa. However, forage peas, clover, canning peas and even ground nuts without earth in the bale and a reasonable ration of leaves can be taken into account.

The old struggle between the shepherd and the crop farmer almost always leads the grower to delay the harvesting date and to “profit” from higher yields, which in most cases also means lower digestibility. The cowherd must never be tempted and must take great care to ensure harvesting on the optimal date. The cut crop should always be baled at night with low humidity and no compromise whatsoever on quality.

Harvesting should coincide with the beginning of flowering. How it is baled and laboratory testing must be integral parts of the decision making process when choosing the material, its suitability to each branch and the appropriate price to be paid. Legumes can be graded only in terms of cell wall, protein and ash testing and as presented here:

- Grade 1: Less than 40% cell wall and more than 19% protein
- Grade 2: 40% - 45% cell wall and 17% - 18% protein
- Grade 3: 45% - 50% cell wall and about 16% protein
- Grade 4: More than 50% cell wall and less than 16% protein

In all circumstances, when assessing legume quality, ash percentages must be taken into account, especially when any additional ash is in fact soil.

The grading system given here is flexible and illustrates the overall framework, the relative value and the place in the ration. For cows in milk, we will try to select hay graded 1 and 2; hay will be included in the ration as between a quarter and one third of the total roughage. The lower grades
can be fed in the fattening sheds at a level of half a kilo per head, which is about one third of the roughage. It is also the accepted level for heifers and once again, as one third of the total roughage, it constitutes about 70% of the total dry matter in the ration.

Legumes in general, including alfalfa harvested at an advanced physiological stage, when most of the plants are in full flower and when various diseases have harmed the leaves on the plant, can contain substances similar to sex hormones (phytoestrogens). Such substances have a negative effect on fertility, as cattle ingest them along with the plants and this is a danger that deserves attention.
Food Byproducts and/or Opportunistic Foodstuffs with Short Shelf Lives

Food byproducts are all those foods not pre-designated as cattle feed, such as grass, silage, etc. The range is large – various meals, wheat bran, gluten feed, DDGS and others are byproducts from the food processing industries, which for many years now have been a fixture as foods included in the range available for the dairy farm. This chapter will discuss these food byproducts which are often sent to landfill, and where they pollute the environment, their value being lost.

As mentioned previously, the secret of ruminant success all over the globe, in deserts and at the distant poles, is the fact that they can produce some meat and milk from any organic material, which can be broken down by microorganisms.

The problems are the cost of transportation and shelf live for the various materials. If governments would seek to act wisely, they would subsidize the use and exploitation of these materials, if only for environmental health reasons and to exploit resources to the full.

Over the years, a number of these materials have entered regular use:

- Beer brewing waste is a byproduct of the beer brewing industry, which ferments barley grains. This is a foodstuff high in protein and cell wall, all of which has high digestibility.
- Beet pulp before drying contains high levels of soluble carbohydrates and as calculated dry weight, it has an energetic value the same as or a little higher than cereals. Dry pulp, after heat and drying treatments, has for many years been a fully paid up member in the concentrates club for the dairy farm.
- Beet molasses or sugar cane molasses – the byproducts after extraction of sugars from the plants. It contains high concentrations of minerals and proteins, mostly soluble proteins. CMS (Condensed Molasses Soluble) are also high in soluble protein and today, either with or without molasses they are standard additives in the ration.
- Citrus peels – a high energy food with a specific advantage because it contains high levels of pectin and non-structured carbohydrates. When fresh, citrus peels can be used on a daily basis and after fermentation and preservation, they can be used for long periods. As is true for dried pulp, dried citrus peels are also a good quality, standard component in the ration.
- In tropical regions, wastes from the banana growing industry are in widespread use, usually to feed mothers of meat calves and the calves themselves. In some tropical regions, the cattle are also fed sugar cane waste after extraction of the sugar, which is a high fiber food with very low value.
- Whey and other milk processing wastes are usually fed to pigs. Whey has a high energy value and other milk processing wastes contain considerable levels of both fat and protein. Whey is transported as a liquid, which requires a fleet of tankers and it is therefore difficult to exploit this resource to the full. In a local initiative in Israel, milk...
processing wastes are mixed with highly absorbent materials such as wheat bran, which extends shelf life and makes transportation more efficient for medium distances.

- Dried, soy hulls processed into pellets are a high quality feed, which provides initial fiber and therefore, it is very efficient when the requirement is for a low volume, concentrated food. Non-processed soy hulls provide a slightly more effective fiber, but because they have high volume, their transportation to any distance is very expensive. In Israel, at the initiative of one of the factories, soy hulls are mixed with molasses, which is a processing byproduct and as is true in the case of milk processing wastes, the mixture creates a new product which can be transported to the dairy farm with relative ease.
- In contrast with soya, cotton seed hulls are only filler material with very low digestibility.
- Almond hulls are a high quality food, rich in digestible fiber, but that is true only for the green, outer covering of the shells.
- On condition that they are sterilized properly, organic wastes from kitchens can also be a source for high quality food for beef cattle and replacement calf rearing.
- Poultry manure from broiler chicken is a good source of protein for beef cattle and calves. In order to turn poultry manure into cattle feed, it must undergo a sterilization process to destroy pathogens. Foreign bodies and lumps must be removed. In Israel, where this source of food is forbidden for milking cows and fattening calves one month before marketing.
- Bread returned from retail outlets, if supplied without mold and packaging remnants can be a good alternative to forage grains and like bread, other baking wastes can be used, with just some doubts about those products containing high levels of fat.
- Potatoes, carrots and other vegetables are good sources of available energy in the rumen, on condition that they are supplied fresh and without soil.
- Wastes from citric acid manufacturing are high moisture materials with some 20% dry matters. They are high in energy, low in protein, with some similarity to citrus peels.
- Grape processing waste is a low value material, high in digestion depressant lignin and tannins. It can be used to cover silage pits, but it is not recommended as feed.
- Olive processing wastes, despite their lignin content, can be an efficient food because of their oil and protein content and as such they can be suitable as support for the straw fed to cattle living at maintenance level.
- In some countries, (Western Europe, Canada and Israel), food from animal sources, such as fish meal, meat meal and even feather meal are forbidden as cattle feed because of the fear of disease transfer. In general, these are foods high in escape protein, which can make a contribution to nutrition efficiency.
The exploitation of high moisture byproducts is problematic because of their short storage life and the high moisture content, which can often lead to negative effects, such as overheating, low digestibility and low food consumption.

To summarize this short chapter, we can say that “he who dares, wins”. He who dares to include byproducts will perhaps not reach record yields per cow in his area, but there is a very good chance that of improved profit margins along with a contribution to environmental health.
Food Hygiene and Indigestion

Good storage conditions and proper preparation of forage; silage compaction and covering; preventing the entry of water during storage; proper cutting of the silage in the pit, etc., are all vital factors in dairy success, nutritional efficiency and livestock health.

All damage caused during food storage will increase the risk of mold development which can make the ration inedible.

Molds need humidity and oxygen. If material moisture rises above 12% and there is no ventilation, mold development can result, even when humidity is low. Different molds develop under different conditions. Aspergillum will develop when the temperature is high, and Fusarium when the temperature is low.

Mold can develop anywhere – in the field, the barn and even in the feeding trough. Therefore, in all dairying situations and even if it seems that all is in order, a search will always reveal some mold at low dosages of up to 10,000 colonies per gram of food. Any slight change in food storage conditions will therefore easily cause a rise in concentration to 1,000,000 colonies per gram. Whereas such high concentrations will not necessarily cause livestock deaths, molds may cause a decrease in food value and nutrient supply. Mold may also have a detrimental effect on rumen microorganism populations.

Mold concentrations at levels between 1 and 5 million units per gram of food (even if all the toxins have not yet developed) can be expected to cause a fall in nutritional efficiency of up to 10%.

Molds do not necessarily always manufacture toxins and therefore it is customary to differentiate between different types of mold. Aspergillum, Fusarium and penicillin are considered toxin producers. Whereas other molds will not poison the cattle to the point of death, they will cause a range of symptoms; such as a reduction in food efficiency, a rise in miscarriages and bleeding in the digestive system.

Under reasonable storage conditions, it is likely that there will be no development of toxin producing molds, but close attention to humidity and temperature should be maintained.

During the 1988 – 1989 drought in the USA, there was a significant rise in mycotoxins in maize grain and during 1993 – 1994, which were cold, wet years, there was a significant rise in a different toxin – DON.

Correct storage of forage by keeping the forage dry and well ventilated and most the operator’s sharp eyes will be good insurance against the damage that can be caused by molds (which are our constant companions).
Indigestion, diarrhea and detrimental effects on milk yield are the constant companions of farmers throughout the year. Sometimes it is quiet and sometimes there is an outbreak without prior warning or any ability to predict its coming. When an event does occur, we often have no idea of the cause.

Viral diseases are extremely difficult to diagnose. Often, they have no direct links with food hygiene and they can cause a wide range of symptoms. Diarrhea and low yields are only some of the external signs of viral infections in addition to the chronic diseases of which there is no lack in herds.

Errors in food preparation, such as baling forage with high moisture levels, with or without soil; insufficient compaction of the silage in the pit; insufficient grinding of seed; feeding whole grain to cows in milk, all suffice to cause external symptoms such as diarrhea and a drop in production.

Storage problems, such as the penetration of rainwater into storage areas in the feed center, or a concentrates silo not emptied completely, including thorough cleaning of the inside walls between silo fills, can cause the buildup of organic materials, which spoil over time. Which can fall without warning into the feeder wagon; alone, that is sufficient reason to take great care.

The presence of toxins cannot always be verified. They can be present when visible mold development on the forage is the cause or present without visible signs of mold. Therefore, it is very difficult to provide a trustworthy explanation in a given circumstance, even though the consequences are indisputable.

Preventing Mold Growth
A very large number of different factors can cause what we later see as diarrhea, and therefore, the most important treatment is prevention.

When filling the pit with silage, do all that is possible to compact and seal the pit properly. We will be even more careful when cutting silage out of an open pit and we will leave no material from the cut, aerating on the pit floor in between each feeder wagon. Most certainly, nothing will be left there to spoil from one day to the next. It is a good idea to consider the purchase of dedicated silage extraction equipment when possible and to consider adding silage preservatives, which can extend silage shelf life, even after the freshly cut silage surface is exposed to air and in the mixer wagon.

Forage must be baled without soil at no more than 15% humidity. Do not bale during the hot hours of the day to prevent leaf loss and to preserve the forage’s nutritional value.

Keep the forage hay in a clean, dry storage area; remember that the combination of moisture, heat and oxygen provide the best conditions for the development of mold and thereafter, toxins.
Concentrates and/or the various grains should be regularly checked for grinding quality. Ensure that if grain has not been treated properly, it does not enter the ration. We will also try to abstain from “a few broken grains”, because it is not always possible to see everything with the naked eye and even a small quantity of broken seed must be treated as suspicious. It is important to mention that when grain high in soluble starch such as wheat, is ground too fine, fermentation levels will be high enough to possibly cause acidosis in the rumen. When grains are not ground and grains are digested slowly in the rumen, the result can be a significant reduction in the flow of nutrients through the digestive system.

If necessary, a toxin binder may be used (preferably, in conjunction with laboratory testing). In some cases, yeast cultures have been found to have the ability to clean up a range of toxins.

Most toxin absorbers are clay based, but the most advanced materials also contain other components, which expand the active range for the various preparations to the point where they can raise the cow’s immunity level. Any material introduced must be tested very carefully (by the eye of the farmer or by laboratory), and should only be used after we are sure that the diarrhea and indigestion have been caused by toxins.

Molds, fungi and most importantly, aspergillums as a source of aflatoxins and Fusarium as a source of DON, ZEA, T2 and other toxins are the primary risk factors and they can be tested for and identified in the laboratory.

Sometimes a problem that sometimes arises on the farm cannot be identified; then, such problems must be solved by intuition and experience.
Steps to Prevent the Appearance of Toxins:

1. Minimize humidity: All foods, with the exception of silage and/or byproducts (citrus peels etc.), shall be stored at a humidity no higher than 12% - 12.5%. (Preferably under some roof).
2. Use sensible transportation: From the storage area and the silage pit to the mixer wagon and the minimum exposure to the air after cutting from the pit.
3. Maintain forage quality: Broken seeds, often imported in that condition, changes in color and heating all constitute risk factors, which must be avoided.
4. Minimize waste: Remnants exposed to the air for any length of time constitute a locus for the appearance of toxins.
5. Avoid unnecessary exposure to the air and humidity. Humidity and warm conditions promote fermenting food.
6. Inadequate storage conditions with excessive heat and humidity encourage the development of toxins. Therefore, forage must be stored in clean, dry conditions. Forages imported in bulk transport ships and stored in dubious conditions must be constantly monitored.

Silage preparation must be faultless. Proper sealing of the pit and cutting at the face will prevent unwanted fermentation and they will also significantly reduce the appearance of toxins. Forage must be baled at the correct moisture level and that hole in the concentrates store roof must be fixed before the rainy season begins.
Chemical and Physical Treatment of Forage Grains

Grains are in widespread use as part of the ration, particularly in areas where there is a lack of forage grown on-farm and/or the management policy is to maximize production. The economic realities on the farm are different in different countries and the way in which the various food components are used changes appropriately. In some places, such as in Western Europe, grains constitute a small supplement in a ration based on grass or more extensively of late, maize silage. In North America, the ration is more usually based on alfalfa and maize silage. In other places, almost no grains are used, yields are low, but they seem to suit the trading conditions extant, such as in Australia and New Zealand. In Japan and Israel, grains constitute 30% - 40% of the ration.

Grain is a catch all term, but in fact, different grains have very different properties. Sorghum and maize contain starch, relatively little of which breaks down in the rumen and most of that starch is absorbed directly by the intestines, in a manner similar to the process in single stomach animals. Barley and even more so wheat and rye, break down in the rumen at very high rates and only tiny amounts, if any, move on to be absorbed by the intestine.

Nutrition management in different countries and the staple grain in each individual area dictate the preferred local management regime for treating grains.

Experiments performed in Arizona, examining the management regime using alfalfa hay, maize silage and sorghum grains, found that steam flaked sorghum had a very significant, considerable advantage over dry grain. In the Arizona conditions, steam treatment caused a higher rate of starch breakdown; contributed available energy in the rumen and a rise in the efficient use of the locally available roughage.

The Arizona farmer could therefore replace steam treatment with a combination of wheat and barley grains, while the British farmer could avoid chemical treatment by combining maize and sorghum. In practice, each farmer uses the raw materials available in the locale and develops the appropriate methods to treat those materials.

In the UK, grass is the principal forage plant and barley is the leading grain. The grass contains high levels of protein and very easily broken down fiber while the starch in the barley is also easily broken down. Therefore, great advantage is achieved by treating with soda caustic, which reduces starch degradation and enables a small amount of direct starch absorption through the intestine.

It was examined extensively during the 1980s in work done with sheep and published by Orskov in Scotland, where he examined the effects caused by different treatments of barley in a fattening ration, with supplementary hay (see: Table 8).
Table 8: Comparison of Different Treatments of Barley on the Consumption of Hay and the Overall Ration.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hay Consumed (Gram dry weight digested / kg $W^{0.75}$)</th>
<th>Dry Matter Consumed (Gram / kg $W^{0.75}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole grain</td>
<td>42.1</td>
<td>83.5</td>
</tr>
<tr>
<td>Grain treated with caustic soda</td>
<td>43.0</td>
<td>80.4</td>
</tr>
<tr>
<td>Rolled grain</td>
<td>34.9</td>
<td>76.8</td>
</tr>
<tr>
<td>Ground grain</td>
<td>34.4</td>
<td>76.7</td>
</tr>
<tr>
<td>Ground and pelleted grain</td>
<td>3.05</td>
<td>70.9</td>
</tr>
</tbody>
</table>

- $W^{0.75} =$ Metabolic Body Weight
- The difference between the amount of hay eaten and the total food consumption is the quantity of barley dry matter consumed.

In this experiment: the longer the grain, the greater the positive affect it had on the entire ration.

Other work, published later (Table 7), graded the links between the physical treatment applied to a grain and the rate at which that grain breaks down in the rumen as follows (graded from residual to decomposable):

1. Whole without treatment
2. Rolled
3. Ground
4. Pelleted
5. Steam

<table>
<thead>
<tr>
<th>6. Grain</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Fast</td>
</tr>
<tr>
<td>Barley</td>
<td>Medium</td>
</tr>
<tr>
<td>Oats</td>
<td>Slow</td>
</tr>
<tr>
<td>Maize</td>
<td>Steam Flake</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Wet Grain</td>
</tr>
<tr>
<td>Barley</td>
<td>Dry Rolling</td>
</tr>
<tr>
<td>Oats</td>
<td>Dry Rolling</td>
</tr>
<tr>
<td>Maize</td>
<td>Whole Grain</td>
</tr>
</tbody>
</table>

Table 7: Grading Different Grains for Use as Feed According to the Rate that they break down in the Rumen.

Given that many farmers have not yet understood the full significance of this issue, research repeating these experiments continue to be published which confirms the trends mentioned above. A study published by Callison S.L.; in Journal of Dairy Science 84: 1458-1467 (2001), sponsored by the Israeli dairy School
reports on an experiment in which maize grains were ground to different sizes of 1.2mm, 2.6mm and 4.8mm. The experiment found that the smaller the average particle size, the higher the combined digestibility in the rumen and the other segments of the digestive system. The researchers therefore recommend always supplying fine ground maize grain.

Another study, examining steam treated maize, compared with dry treatments, found that when maize was the only grain supplied, steam treatment had the advantage. When wheat silage is the most important roughage component (and other grains supplied includes low cost wheat and barley alongside relatively expensive maize), then make every effort to supply the maize ground fine and the barley rolled; both without moisture and steam. If the price of barley is high and the proportion of maize in the ration rises, then the correct method would include some of the maize as rolled maize (in order to provide some improvement in rumen breakdown rate) with the other, larger proportion of the maize supplied finely ground.
Recommended Structural Dimensions for Cows

Nutrition and food supply management regimes sometimes fail by not considering the space requirements needed by cows to be healthy and have a proper diet.

An ancient Jewish proverb states: “He who prepares for the Sabbath, eats well therein”. By preparing a proper infrastructure, the cows are able to produce to their full potential. The opposite will be true for those stinting on infrastructures and trying to find magic solutions for the food supply, the additives etc.

The important measurements for the air and space required by the cattle are given here below:

- Walkway in front of the feeding trough: 3.5 meters wide net, under a roof and 4.5 meters in the roofed loose housing (for those willing to add that bit extra, they should include rubber mats over the concrete surface).
- Feeding trough curb on the walkway side: 0.55 meter, when there are no individual stanchions in front of the trough and 0.45 meters when there are stanchion bases in place.
- Feeding trough height: 10cm – 15cm above walkway height. When eating, the cow’s head should slope downwards which stimulates the cow’s flow of saliva. Increased saliva provides the correct chemical environment in the rumen and improves food efficiency.
- Feeding trough area per cow: No less than 75cm, so when the food is delivered, every cow has her place. Where possible, a slightly wider area is preferable to provide more comfort for each cow and is more convenience for the dairy farmer.
- The feeding alley must be at least 5 meters wide. The first meter, onto which the food is unloaded, should be as smooth as possible with ceramic tiling (which will improve cleanliness and will encourage the cows to eat).
- Food should be pushed back using small equipment such as a bobcat pushing a tire or an angled push plate. Mechanical brushes are commonly used in Italy, but any similar, small tool can do the job, as long as the wheels of the heavy equipment used by many farms for food delivery do not ride on top of or close to the food.
- A pipe or cable at a height of 135cm above the walkway will separate cows at the feeding trough and it will extend out over the walkway by at least 15cm. Those who prefer tie stalls should also make them lean outwards, because the more comfortable life is for the cows, the higher the yield. If there are any doubts about the pipe leaning out, pipe height can be raised to 140cm.
- Lying area: In a loose barn, we must ensure a minimum area of 20 square meters per head (those who can should add to this dimension as much as they can), though 30 square meters is recommended. In a loose barn, there will always be fewer cows than in an equivalently sized tie stall barn.
- Structure direction: As appropriate to the lay of the land and the prevailing winds, to achieve maximum wind throughput on the wide side of the structure. Wind flow is a critical factor.
during the summer in all hot climates. However, it is also important to ensure that there is minimum radiation from adjacent buildings.

- Screens, curtains or any other technique used to close and open the structure for ventilation and/or prevent the entry of wind and rain in the cold days of winter.
- Yard: Always a good idea, but where impossible, it helps if the roof can be opened during the summer nights.
- Drinking troughs: As many as possible, where the cows exit from the parlor and even inside the parlor, which is easy to arrange when constructing a parallel parlor. Along walkways, inside the barns, but always on the opposite side to the feeding trough, this will force the cows to move within the structure. Calculation of the number of feeding troughs will take into account at least 20cm – 25cm per head. Tie stall barns shall include additional, personal water troughs for each pair of cows. Water height in the trough shall be as low as possible using the same principle as that used for the feeding trough, but water units should have side protection to prevent secretions and dirt entering the water trough.
- Cooling: In the holding pen, where the cows wait before entering the parlor, there should be fans to draw in the natural wind. Given that water is an expensive input often in short supply, nozzles used to cool the cows will have sufficient flow to dampen the cows in a short time in the holding area, but they will not be used along alleys, where they have low efficacy and they are wasteful.
- Rubber mattresses: As many as possible on concrete surfaces and most importantly in the holding area.
- Preventing rain entering the barn: A recommended, efficient solution is to install a movable curtain, which can be closed and opened easily as the weather changes.
- Care of the lying area: Everything that can be done should be done to keep lying areas dry at all times. Cultivators with broad shares in front and lines of narrow shares behind to break up clumps should run through the entire barn lying area once or twice a day. Manual or mechanical leveling out of bedding at least once a day.
- Roof height: 8 to 10 meters in the center with an opening of about 20cm and up to 5 meters, with an overhang of at least one meter each side.
- Number of cows in a group: Experiments have found that there should be no more than 60 – 80 cows in a group. There are of course larger groups because of the farming realities, but it would be preferable not to have any group with more than 100 cows.
- Calf group size: Small groups for each age group and the different feeding requirements at each age. Living space for calves: 6 – 8 square meters when very young and up to 15 square meters for insemination and pregnant heifers.
- Dry cows: 15 square meters should be enough, but there should be an individual space of some 10 square meters per head during calving. Preferably, there should be an open cage for the suckling calf in the calving yard, which allow the cow to lick the calf during the first few hours after calving, but at the same time, the cage will prevent the newborn from suckling.
Food quantities are discussed separately and as has already been stated: Even the very best fuel will not improve the journey if the road is in disrepair and the driver does not know how to drive.
Managing Calf Rearing
Calf rearing is the first stage of a high yielding, healthy milk cow. Rearing calves for replacement is not cheap, and there is no substitute for proper rearing. Cost savings will be achieved through the production levels after calving and rearing, by rearing only those calves needed for herd replacement. A static herd with an annual replacement requirement of 25% - 30%, must rear some 0.7 calves per milking cow. Surplus calves must be transferred to fattening at an early age. All cows that fail to become pregnant by the third insemination or by 200 days of lactation must be designated for insemination by beef breeds. A herd in growth or development stages (higher marketing quota is expected) will retain and rear all the calves born (but when reaching the economic analysis stage, rearing costs will be written down as an investment).
From my personal experience with a large dairy herd in Eastern Europe, I learned how important it is to rear calves with the greatest possible care and attention. The herd included a wide variety of cows from different breeds. Not enough data was available about each individual cow’s genetic history and the average yield ranged from 18kg to 20kg milk per cow per day. The herd owner was persuaded to invest in calves. The result – Within three years, the generation of cows born on the farm reached yields of 38kg – 40 kg milk per cow per day by the second month after calving.

The manner of investing in calves will be discussed later.

The rearing process must be rigorously controlled and must not be disrupted by unnecessary, so called savings. There are a number of stages in the process. Each stage has an associated ration composition and management system, which depends upon the calves’ age and physiological status.

We are all familiar with the examination of the link between the animal’s body composition and the developmental stage the animal has reached as illustrated by Graph 2 below, which emphasizes the links between the composition of the animal’s body and the developmental stage. We learn from this graph how important it is to provide the appropriate ration for each developmental stage in order to prevent the accumulation of superfluous body fat.
The Stages
The newborn calf does not regurgitate cud. The calf’s real stomach constitutes some 70% of the total stomachs, compared with 7% in an adult cow. Owing to the structure of the placenta while the calf is in the womb, there is no transfer of antibodies into the calf and the calf is born exposed and vulnerable, without any active immune system. The natural way for the calf to acquire the antibodies essential for all animals’ normal existence, is through the ingestion of the colostrum, which a very high concentration of antibodies has given to the calf during the first few hours immediately after calving. At the same time, immediately after calving, the newborn has a highly developed ability to absorb antibodies, which vanishes after a number of hours. This teaches us that during the first stage of calf growth, to ensure that it stays healthy, the calf must be fed up to four liters of colostrum during the hour immediately after birth and preferably, that colostrum will be from a mature cow and not from a heifer. If the calf has difficulty consuming that quantity of colostrum, we must still ensure that at least two liters are consumed during the first hour and an additional two liters will be given about four hours later.
The Feeding Stages of Calves:

1. Birth until weaning: Milk with a starter mixture (preferably a pelleted concentrate to encourage eating and to avoid dust and waste) with 18% protein in the dry matter. At this stage in the calf’s development, it is inappropriate to include fiber rich foods, because the concentrated foods are more conducive for the development of papillae in the stomach wall. Calves kept in hutches must have their starter mixture replaced and renewed every day to ensure that they are encouraged to consume the maximum.

2. Weaning to four months: Starter mixture + a small quantity of milking cow TMR, which will be finished during the day (concentrates and milking cow TMR will be delivered fresh and will be replaced in a clean trough every day).

3. 5 – 7 months: Milking cow TMR reinforced (and/or diluted) by 1kg – 1.5kg of legume hay each day. During this period, those who are willing and able, should preferably prepare a designated mixture with a protein content of some 16% and a net energy concentration of 1.5 mega calories / kg dry matter. Most or at least 50% of the roughage should be high quality legume hay.

4. 8 – 12 months: A designated mixture, containing about 70% roughage with legume making up at least one third of that roughage or even more. The mixture shall contain 15.5% protein and 1.4 mega calories of net energy. As a compromise, when it is impossible to prepare a separate TMR for this group (and a compromise is not as good as the original), it is possible to combine calf mixture with milk cow mixture at a ratio of 1:3.

5. 12 months to Pregnancy: Calf mixture containing some 70% roughage (preferably legume), 13.6% protein and 1.32 – 1.34 net energy. Calves are brought for first insemination at 14 months. Animal height is the most accurate method to determine the suitable insemination date. In most milking breeds, the recommended height is 124-125cm.

If regular, properly organized height measuring is difficult, the recommendation is to draw a line in an obvious color at a height of 124cm on the outer side of the calf feeding trough. From a reasonable distance, this is an excellent way for the stockman to keep a check on calf growth to the appropriate stage. When planning spring calving in a group, as an effort to improve summer production levels, the calves’ first insemination can be brought forward or delayed as necessary, because cows’ first lactations are more persistent than mature cows’ lactations.

Pregnant heifers shall be fed a calf mixture similar to that given to calves up to insemination. If possible, it is worthwhile to consider a different mixture, specifically, a mixture with a lower energy level (1.27). If that is not possible, a regular calf mixture should be supplied but to avoid laying down fat, it should not be freely available. Cows should be prepared in a similar manner.
at the parallel stage, during the last three weeks of pregnancy. When possible, it is preferable and recommended not to house heifers together with cows, at least up to the calving date.

Supplementary Comments:

- The energy values recommended above are as calculated according to NRC89.
- The inclusion of legumes in the calf ration will augment the production of microbial protein and will prevent a rise in the level of urea in the blood. Legumes make a very considerable contribution to correct development of body weight and height and there are other advantages in terms of fertility. Legume ability to augment the production of microbial protein, which occurs in synthesis with the energy available in the rumen, prevents a rise in rumen acidity (SARA) and in turn, contributes to a reduction in the incidence of laminitis.
- By the weaning stage, calf management in hutches is not only a recommendation; their advantages have been proved experimentally. There is less disease and stronger connections between the human caregiver and the animals, which in turn leads to friendlier and calmer cows in the future. (An experiment conducted some years ago at the University of Indiana found that calves grown in hutches without any connection whatsoever with other calves and even without any line of sight to other calves, were calmer adult cows and gave more milk than calves grown using standard management practices.) A farm with weaning calves in groups would do well to distribute concentrates and lock the calves in the feed stalls during and immediately after feeding them milk. The concentrates and locking for a fixed time will ensure that the calves will not suck on each other, which is the typical behavior of mammals living in a group. After weaning, the calves will be transferred into small groups of 5-6 calves for a period of 3-4 weeks and only after that period has passed will they be transferred to a regular group management system.
- Calf quality of life is a vital factor in their development. When calves are grown without feeding trough space for all the calves and with just re-filling of the food (so called free feeding), group crowding and moisture will lead to the development of every possible mischief – starting with non-uniform development because the stronger calves bully their way to eating all the best food, leaving just remnants for the others. There will be a detrimental effect on the quality and convenience of calf maintenance and that is another source of fertility problems, laminitis and more…
The following is an example of calf measurements (weight and height) gathered when monitoring the rearing program. It shows that when using the correct management system, it is possible to achieve results even better than the standards suggested by the researchers.

Graph 3: Rate of Calf Weight and Height Change during Rearing

A good look at this graphic example, illustrates the difference between the weight rise curve, which is linear and calculated according to an average rate of 0.8kg per day and the height rise curve, which goes through three stages, each of which has a different development rate. That is the reason for emphasis on the importance of high levels of nutrition while the calves are young and lower levels in more mature calves and pregnant heifers. The model given in the graph above is not the only model; other models give a slightly different picture. Most importantly, the principle illustrated by this graph indicates the strong links between calf age and calf skeleton growth.

The dry period is the most important period in the annual nutrition cycle after calf rearing. It is the time when to whatever extent possible, we can compensate for the problems incurred during the year.
The dry period is designated for the preservation of the cows’ body condition, but it is also the time to ensure that the cow is receiving the quantity of nutrients required for good development of the fetus, which makes great demands on the cow at this stage in its development. It is vital to manage the dry period properly to prevent metabolic disease (further details about that topic in the next chapter) and milk fever; to maintain rumen volume and to prepare the cow for the stage after calving. The problem we face is how to determine the drying date because we have no way to predict the length of the gestation or the calving date. Standard practice is to assume that a normal gestation lasts between 260 and 300 days, for an average pregnancy of about 278 days.

The Recommended Management and Nutritional Alternatives during the Vital Dry Period

- The standard dry period lasts 60 days (cow dried off at some 220 days of pregnancy).
- “Fat” cows – no more than 60 days and even slightly less. “Thin” cows – It is probably possible to extend the dry period slightly to a maximum of 70 days
- The close up, preparation period will last between 7 and 28 days and will have the following order:
  - “Fat” cows: (body condition score above 4) just 4-7 days
  - Body condition score 3.5: About 10-14 days
  - Body condition score 3: 21 days
  - “Thin” cows (body condition score of 2.75 and below): Up to 28 days

The ration for dry cattle shall contain some 12% protein, at least 80% roughage (legumes are not suitable in a dry cow management regime because they have high concentrations of calcium and potassium) and 1.4 mega calories of energy.

- The close up stage ration should contain 14.5% protein, 60% roughage and an energy concentration of 1.55. When the management system divides the dry cows into two drying sub-periods, a problem could arise because a preparation period of 21 days might not suffice to prepare the rumen for the next chapter – lactation. **This finding has led many researchers and farmers to consider a shorter drying period.**
- When policy dictates a shorter drying period, it is essential to provide a relatively rich ration (see table below) throughout the drying period without close up period. If organized properly in terms of buildings and nutrition, a short drying period might well produce better results than the conservative management system described above. However, not all farms can form the alternative regime properly. Given that heifers have good persistence, their drying period can be delayed to 232 – 234 days (45 drying days on average), while 220 – 222 gestation days is a more appropriate date for older cows. The literature does indicate improved fertility after a short drying period.
The Range of Foods and Ration Composition for the Dry Cow

The preferred roughage for dry cows is the designated TMR containing a combination of grass or wheat silage and whole crop wheat hay. Silage has a positive effect on mineral uptake rates and that is its advantage in the prevention of metabolic disease and most importantly, milk fever. Milk fever is caused by a lack of calcium, expressed as damage to the nerve endings, which causes paralysis. To ensure that it will be possible to prevent this problem, during this period it is necessary to encourage the release calcium caution from the bones. Illogically, rations rich in cautions prevent this positive process. In such circumstances, the standard solution is to add to the dry cows’ ration, anion salts which will neutralize the damaging effect. Experience has shown that the combination of vegetative silage and low caution foods, together with close monitoring of the calcium / phosphorus ratio to ensure that it does not rise above 1:1.2 will prevent the appearance of the problem and no anion salts are required when feeding in this way. To balance the calcium / phosphorus ratio, current recommendations advice abstention from the inclusion of high phosphorus concentrated foods, such as bran and gluten feed. Grass silage given freely to dry cows often provides a complete solution for the problem of milk fever, when compared with a parallel group of cows consuming the same grass either cut fresh or in pasture.

Oat or whole wheat crop hay can be given to dry cows as the sole roughage component, on condition that it contains at least 10% to 11% protein. Using this management system, it is necessary to add a specific concentrate during ration preparation and perhaps at a lower proportion throughout the dry period. It is important to take care when choosing the source for the hay, because the plants were wilted down to produce the hay. Hay that was grown in stressful conditions may also cause excess nitrates, which can cause abortion.

Notwithstanding the wish to adapt the rumen in preparation for the ration after calving, no recommendation can be made to feed them milking cow rations during close up, primarily because of their salt and mineral content. If it appears there is a need for something beyond the dry cow ration and/or the hay and designated concentrate, a small quantity, which shall be no more than 1kg dry material per head, can be added at the TMR close up stage.

Balancing the ration for dry cows must include 70% - 100% roughage, according to the source of the food, its influence on rumen filling and its breakdown rate. Rumen filling is absolutely essential in order to prevent any reduction in rumen volume, which will cause a change in the location of the true stomach (usually to the left, but sometimes to the right), which will prevent the transfer of digesta into the digestive system. This inversion of the stomach is a nutrition problem which can and should be prevented. If it does occur, veterinary intervention is the only solution.
Table 9: Examples of Typical Ration Composition for Dry Cows in Israeli Dairying *

<table>
<thead>
<tr>
<th>Food</th>
<th>% Dry Matter</th>
<th>Content</th>
<th>Value as a %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat silage</td>
<td>35.0</td>
<td>Net energy</td>
<td>1.46% **</td>
</tr>
<tr>
<td>Whole wheat hay</td>
<td>30.0</td>
<td>Total protein</td>
<td>13.0</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>10.0</td>
<td>Calcium</td>
<td>3.6</td>
</tr>
<tr>
<td>Rolled barley</td>
<td>7.0</td>
<td>Phosphorus</td>
<td>2.7</td>
</tr>
<tr>
<td>Ground maize</td>
<td>7.0</td>
<td>NDF</td>
<td>47.0</td>
</tr>
<tr>
<td>Soy cake</td>
<td>10.0</td>
<td>Roughage dry matter</td>
<td>75.0</td>
</tr>
<tr>
<td>Vitamin concentrate ***</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Example of a ration appropriate for a drying period lasting some 45-50 days.
** Calculation of net energy in mega calories according to NRC 89 and local experience.
*** Vitamin A: 100,000 units per cow per day. Vitamin E: 2,000 – 4,000 units per cow per day.

Comment: On farm experience of the ration described showed no advantage in or any need whatsoever to add anion salts. Contrastingly, in those places and for those rations with high caution levels (calcium and potassium), such as rations containing alfalfa, we must think about adding anion salts to prevent metabolic disease and principally, milk fever.

Ketosis and Negative Energy Balance
During the second half of the 20th Century, milk yields in Israel did not go beyond the 6,000 liter barrier, or to be more accurate, the average recorded yield during the year 1966 – 1967 was 6,081kg with 3.24% fat for farms milking three times a day. Family farms milking twice a day reached an average of 5,355kg with 3.35%. Overall average for all farms reached 5,873kg with 3.30%.

In the November 1968 edition of Israel Cattle Breeders Association’s journal, Professor Raanan Volcani published a revolutionary article entitled: “Towards 12,000 liter yields”. Amongst other comments in the article, the author predicted that a rise in yield would require “breeding a trait for ketosis resistance” and he also estimated that “maintenance of the percentage fat level in the milk… will prevent growth in milk yield, which is the increase in the annual production of protein”.

sponsored by the Israeli dairy School
Professor Volcani must be given his due for his vision, but there has been an almost doubling of milk yields along with a rise in fat percentages and a relatively high level of protein has been maintained, even though protein levels were not usually checked in those days.

As understood it today, ketosis is a management problem, which grew with the rise in annual yields. Often, ketosis appears when the dry period is long and the lactation is longer than 400 days. Low yields before drying off leads to fat accumulation and consequent ketosis. A long drying off period also presents risks but most important of all, ration composition and feeding regimes can reduce food consumption and the supply of energy.

Ketosis can be prevented by returning to the 1966–1967 yield levels but it can also be prevented by using the work methods commonly used on a number of farms at the end of the 1970s. The nutrition regime for dry cows comprised of only low quality whole wheat hay and/or only maize straw. The result was that whereas ketosis was prevented, at the same time, yields and colostrum quality were much lower.

Progress has been made in yields; properly organized dairy farms are building and genetic advances are at our disposal. With all that, an extensive problem of ketosis still exists; a matter for concern.

Some of the solutions are quite simple:

The period between calving and drying off includes rest days and subsequently, the non-milking days and the lactation, which shall last for no more than 380–400 days. This is an easily achievable management regime and it has an enormous effect on calving diseases, including ketosis. There are those who have used a management regime including postponement of first insemination until after 150 days of lactation for some of the cows in order to raise the level of milk solids and save insemination costs. This management regime creates a vicious circle of ketosis and lower fertility. Today we know that it is possible to inseminate healthy cows in heat as early as 60 days into the lactation and there are no problems associated with this regime. The problems are what to do with the cows that do not come into heat and how to help them. The correct management regime for rest days should begin with the heifers and all the healthy milking cows should be inseminated after 60 days of first lactation, along with careful veterinary examination of those cows not coming into heat until beyond some 70 days into the lactation. Together, with firm emphasis on proper (no false savings) rearing of the calves it is likely that in the future, the number of cows with irregular heat cycles will be reduced and that will allow us to take another step forward.

Reducing the number of rest days and days open will significantly reduce the number of cows dried off in excess body condition. In such circumstances, we can shorten the dry period and dry off the cow when it reaches about 220-230 days of pregnancy, (as stated above) which will ensure an average dry period of some 45-50 days. It is possible to work in and recommend these conditions only if the dry cow yard provides at least 15 square meters of lying ventilated area per
cow, with a clean and easily accessible feeding trough with a correct, balanced ration delivered as a TMR throughout the dry period. If possible, it is highly recommended to separate heifers from cows and to prepare a designated calving pen to be used during the last few hours of actual calving. The results to be expected when managing in this way will ensure a significant reduction in calving diseases, together with improved fertility during the following lactations.

A long dry period is more damaging and more cause for concern than a short, 40-50 day dry period. The problem is that the gestation length is uncertain for which reason the benchmark is set at 220-230 days. Only a small number of exceptional cows will reach 70 dry days, but no more. Alternatively, some cows with a dry period of only 40 – 48 days, but they will be accompanied by a highly nutritious ration and comfortable living conditions, which should even be advantageous as discussed in the previous chapter.

Ensure the cow’s comfort: High quality food and a ration without mold, that has high digestibility to ensure maximum consumption and providing an adequate supply of energy; this will reduce the cow’s need to exploit body reserves. The stockman should ensure peace and quiet for the cows, with no blows, pushing or shouting. No maintenance work should be performed while the cows are lying down and chewing their cud. A comfortable, spacious, uncrowned and clean lying area with plenty of space at the feed bunker should be provided. Ensure all these optimal conditions and make certain that the milking parlor is maintained properly. See that cows are properly milked which will even reduce the number of somatic cells and udder infections.

A negative energy balance and ketosis go hand in hand; the problem can be solved by knowing how to take measurements. A normal cow reaches its peak energy production on the third week after calving (calculating milk quantity x fat percentage). Therefore, what we can actually see with our eyes or observe on the computer graph is already after the cows have reached peak energy production. Therefore, we have a problem with the commonly accepted benchmark of “peak milk” because it is meaningless in terms of energy and metabolism. If we wish, that is another good argument to recommend insemination in 60 days of milking for every cyclical and healthy cow. Based on that, it is impossible to draw any conclusions about ketosis because the cow who is fat after calving (from the reasons described), consumes less food, breaks down more subcutaneous fat reserves than can be handled by the liver and is therefore more susceptible to disease.

Ketosis and metabolic diseases are not curses from on high. Most of the solution is in our hands and if we act appropriately, we will be able to maintain high levels of fertility, even at production levels reaching 13,000 kg – 14,000 kg milk per cow, with reasonable solids levels reaching 3.8% fat and 3.3% - 3.4% protein. Even higher figures will not necessarily be an impossible target.

Day by day, published studies explain the reasons for and the hormonal background to the drop in fertility that accompanies a rise in yield. It seems that the solution proposed here - improved
management and a better balanced ration, will result in a rise in yield, without any drop in
fertility and that is a finding now observable at a not inconsiderable number of working farms.

There are no easy answers to the question – How do we prevent ketosis and a negative energy
balance? The management regime as proposed in this chapter indicates which tools can be used
to minimize the appearance of ketosis. It entails considerable effort and it is not easy, but it
works and pays off. Even if we only achieve a fall in the number of events, that effort will still be
worthwhile.

Managing Nutrition after Calving
After nurturing the cow carefully through the dry period, paying attention to the length of the
period, sorting the cows into close up groups according to body condition and mixing the dry
period ration and the additives for good preparation, it is especially important to provide a
designated, proper management regime after calving.

On the day it calves, the cow goes through a crisis, which is to a great degree, unpreventable. In
most cases, the difficulties, pain and trauma cause a significantly detrimental effect on appetite
and therefore, there is a drop in the supply of vital nutrients. The chance for metabolic disease
(ketosis, udder fever, placenta retention, etc.) increases.

It is commonly thought that during this time cows have relatively good abilities to exploit the
body’s fat reserves except for the replacement of the temporary lack of protein, which is difficult
to extract from the body’s reserves. (There is very little protein reserve) The standard
recommendation is to raise protein levels for the period until food consumption recovers.

The search for a solution to this problem has led many to provide the cow with protein rich
concentrates after calving and to presume that the problem has been solved. However, the
addition of protein rich concentrates usually has the opposite effect. Dry matter intake does not
rise; the supply of energy is depleted because protein has low efficiency as a source of energy.
Because the percentage of roughage in the ration is lower, rumen filling is inefficient. The lack
of fiber food gives rise to worries of rumen inversion and an energy supply failure.

The correct combination of rumen filling and maximum food consumption provides a solution
for all the cow’s needs according to physiological and nutritional measurements. The solution
lies in the preparation of a designated ration for the short, three week period at the beginning of
the lactation. That ration must be based on high levels of the best quality roughage that can be
found (alfalfa hay or even early wheat hay), maintaining the energy concentration, and a (not too
steep) rise in protein to reach 18% - 18.5 of dry matter, achieved by providing high quality,
protein rich foods such as soya and canola. The quality of the protein in alfalfa combined with
the maintenance of the energy concentration, and the source of the carbohydrates (maize grain as
the source of available starch, which is absorbed through the intestines and barley as the supplier
of energy available for microorganism activities) are the basis for the ration. In specific
circumstances, preparations providing sugars almost directly can also be added (such as propylene glycol or glycerin) to ensure that the target is reached.

On those farms unable to provide these cows with separate quarters and a designated ration, effective feeding trough management is the most important factor.

Nutrition Management During Lactation

After the end of the first three weeks of lactation, during which the cow’s needs are greater than its ability to consume food, the group management system must be re-examined with a view towards the remaining lactation period. In the past, it was common practice to supplement the ration with a quantity of concentrates per cow, as a function of daily milk production. Today, a mix is supplied which augments the diet; the mix has greatly contributed to the dairy industry around the world. Before determining the policy and the nutrition management system, it is worthwhile considering the following:

- Dry matter intake continues to rise until the 10th week after calving and then stabilizes before beginning to drop.
- Peak milk yield in terms of energy (%fat x milk quantity) is reached as soon as the third week after calving.
- Milk composition and energetic value change along the lactation graph. As a general rule, solids levels (fat and protein) are higher after calving and are at their lowest 4 to 8 weeks into the lactation cycle and then rise incrementally until drying off.
- There is a direct relationship (see graph below) between milk production in weeks 2 – 3 after calving and the yield potential for the entire lactation; that relationship is the yield potential for the current lactation.
- Production persistence (the milk graph gradient) is influenced by the cow’s age (younger cows tend to have greater persistence than older cows) and the composition of the ration supplied (greater persistence when the ration contains a higher percentage of fiber foods).
- Cows with low potential, overly fat, or suffering from acute metabolic disease at the beginning of the lactation tend to reach drying off with less food efficiency.
- Frequent changes in the composition of the ration delivered (feedstuff and composition changes) have an adverse effect on persistence, a negative effect on production and encourages excessive fat deposition before drying off.
- When the management system provides one single ration or when using any other management system as selected by the farm, there are advantages in dividing the cows into groups by age (parity) due to herd behavior problems and differing needs; this is especially true with 1st calving animals which are still growing. The researchers Phelps and Prow (1992) found that separation into parity groups housed in different yards, without any differences whatsoever in ration composition, made a positive contribution to 1st parity animals. Food consumption and associated annual production went up by an average of 725 kg of milk.
Large dairy herds can exploit the information given above to the full by moving using a three ration management scheme (see: Appendix 2) where one of those rations is designated for the short period immediately after calving. Other advantages of the three ration system include lower feed costs and lower body fat levels at the end of the lactation. Calving cows will be divided up into sub groups by yield. The lowest third (or quarter as appropriate to on-farm experience) in each parity group above the 1st ones, will be transferred to a management system with a ration, which is lower cost and lower in energy than the other cows. The primary objective is to prevent them getting too fat, while preserving their milk production potential. The remaining cows and all of the 1st parity animals will be transferred to the “expensive” nutrition system designed for maximum production. After the initial sorting (with the exception of those exceptional cases of extremely thin cows), no more transfers should be made until drying off.

The combination of groups sorted and divided according to potential (at the beginning of the lactation), calving season and cow parity seems to be the optimal group management system, and will maximize production and reduce the incidence of metabolic disease. This management system presented has economic advantages; it prevents disease and over fattening while still providing for considerable savings on ration costs without adverse effect on lactation persistence in low potential cows.

The drawing below is taken from an experiment conducted on a dairy herd in southern Israel. Throughout the lactation, all the cows received the same TMR and their entire lactation data was compared with their yield during the third week of the lactation. It was found that cows giving high yields at the beginning of the lactation, continued to give high yields throughout the lactation. Cows that began with low yields for genetic reasons or for reasons linked to a previous lactation, drying off, calving diseases, mastitis etc., remained low producers throughout the lactation. The opposite result was found when body weight was measured. By the end of the lactation high yielding cows had not yet reached their weight at the beginning of the lactation, while low yielding cows fattened up; they reached a higher weight than at calving or during the period before drying off.
Nutrition management based on potential production criteria requires investment specific measuring instruments. Such instruments are readily purchasable in the marketplace and they include electronic identification tags attached to the cow’s leg or neck. Electronic receivers can provide the stockman with priceless, very extensive information about cow behavior, coming into heat, lying down periods, cud chewing, body weight, milk and its constituents, mastitis, somatic cells and health parameters in general. Electronic receivers help us manage the cows along with an efficient, group nutrition management system. Small dairy farms or in those places where there are organizational difficulties in applying the “yield potential for the current lactation” management system, it is possible to use and even to do well using a single TMR for all the cows in milk and reach better per cow production results and higher overall herd profitability.

An Italian dairy farm constructed a specific feeding model based on concentrates and TMR. All cows received 8 kg of concentrates at the beginning of the lactation cycle. Figures of actual yields were gathered and recorded. The cows, according to the model and feeding norms, were entitled to larger quantities of concentrates, accumulated “rights in the computer program”. When they reached the lactation stage at which normally, according to the milk yield curve, concentrate quantities would be reduced, the model gradually returned the accumulated rights to high yielding cows. Those cows continued to receive 8 kg of concentrates, despite the fact that their yields had begun to drop. In contrast, cows without accumulated rights received less concentrates earlier. This nutrition management system maintained better persistence and reduced the number of cows that drying off with too much fat.

Proposed Nutrition Management System for the Robotic Dairy Farm
Feeding technology on the modern dairy farm has developed incrementally. It began with pasture as the sole food ("TMR mix") and moved on to specific additives and then went back to the mix in advanced technologies. The robotic milking system and the use of individual feeders requires creative solutions for individual feeding that is appropriate for the range of foodstuffs available on the farm.

In Israel, the range of available feeds is different from those available in Northern Europe, where robotic milking was first developed. Instead of grass containing high levels of digestible fiber and between 17% and 22% protein, the roughage at the disposal of the Israeli dairy farm has mediocre fiber digestibility and protein levels of between 8% and 10%, but with more escape protein.

To maintain reasonable levels of digestibility, rumen functioning, saliva excretion and rumen volume, it is necessary to develop a working system for the portioning out of concentrates in the feeding troughs in a manner that will maintain food roughage levels in the combined ration.
Author’s Note:

A friend of mine was a member of the research team at the Technological Institute in Wageningen in the Netherlands, during the development of the robotic milking system. He once called me at midnight on a weekend to tell me that: “the concentrate feeders have stopped working”. He asked me what will happen to milk yields. I answered, “There will be no change”. For short periods, cows have the ability to balance themselves properly without concentrates, on condition that the fiber roughage in the food is freely available in the feeding trough.

Given that milk production at the beginning of lactation constitutes a good indication of yield throughout the lactation, we can use that information to deliver to the feeding troughs, nutrition planned to suit the specific period and to prevent any adverse effects on production persistence. We should also abstain from making frequent changes in the supply of concentrates.

The Work Program when Planning and Allocating Food in the Feeders

- Calculate the normal ration, containing the appropriate level of roughage in the TMR.
- Some 3-4 kg of concentrate components should be removed from the calculated ration and added to the composition of the pellets provided in the feeders.
- Concentrate pellets shall contain all the “adhesion products” (wheat, rye and bran) removed from the TMR but at a maximum of 30% of the pellets; all the other components should be based on different grains providing protein, with a preference for foods rich in primary fiber, such as soy hulls along with a small quantity of vitamins. It is not a good idea to include fat or a large dosage of mineral additives.
- This mix is the components of the ration not included in the feeder pellets, and the level of roughage it contains is higher than that found in the regular TMR.
- The quantity of concentrates during the first 3-4 weeks after calving shall be no more than 5-6 kg, which ensures an estimated food consumption of some 18 kg dry matter, while maintaining the correct proportion of roughage in the overall ration.
- During lactation week 3-4, the cows will be scored and divided up into groups according to milk yield (different benchmarks for each parity group) and two thirds of the high yielding cows will be transferred to nutrition regime A, while the lower third will be given nutrition regime B.
- Nutrition Regime A:
  1. 4-5 kg concentrates in the feeders for up to 200 days of milking.
  2. Adjustments according to milk yield and body condition score.

Thin cows will receive a bonus and fat cows will be gradually cut back to 2kg or 3 kg before drying off.
Nutrition Regime B:
1. 2-3 kg concentrates in the feeders for 180 to 200 days of milking.
2. Adjustments according to milk yield and body condition score as applied in Nutrition Regime A.

Assuming that food consumption reaches its peak at 28kg – 29 kg dry matter, the proposed nutrition regimes will ensure that the maximum number of cows will receive the minimum reasonable quantity of fiber roughage in the total ration.

At the adjustments stage after 200 days of milking, body condition must be the primary factor in the decision on concentrates level. (The aim: A reduction in the allocation of concentrates only for those cows with rising body condition scores.) **Cow body condition must be scored during weeks 3-4 and again during weeks 28-29.**

Nutrition Regime Stability and Sophistication

The cow is a conservative that produces best when its routine is maintained. Failure to do so will have severe consequences:

*In an incident that affected a number of farms the highly soluble, immediately available, sodium bicarbonate used as a buffer was replaced overnight by a different buffer that dissolved slowly. Because the slower dissolving buffer contained a higher relative quantity of calcium, the quantity of mineral calcium added to the ration was reduced. The result was a drop in rumen PH, lower dry matter intake and lower milk yields.*

In this incident, the negative influence of change was caused by the immediacy which it was implemented. If that same change would have been made gradually, no damage would have been caused. **Work on a dairy farm is suitable for people with a marathon mentality and not for sprinters.**

While thinking and decision making processes must be the very opposite of conservative, but implementation must be. The order of the day on the dairy farm must be fixed – clean out the feeding troughs in the morning, delivery of food will be close to the time that the cows exit the parlor and the food will be pushed up frequently, with emphasis on timing it perfectly to the weather and when the cows are not lying down. If there is no urgent need, the cows should not be made to stand; work should not be done in a yard or barn containing cows. Cows prefer serenity and routine.

A great part of our professional lives is conducted in a state of uncertainty. The stock market crashes, natural disasters occur and prosaic political decisions are made on prices and production limits. That very dynamism raises a large number of questions. Does a rise in the cost of forage oblige a change in nutrition policy even though we know that the change will harm nutritional efficiency? Alternatively, is optimum nutrition a pre-condition to profit making and the full
exploitation of yield potential, through the combination of the quantities produced at the price received? Can we compensate for the drop in yield after a rise in food prices by enlarging infrastructure? What is the correct ratio between the number of cows and the number of calves? This problem becomes even more complicated when employing the correct rearing policy; the calves are more genetically advanced than the cows. On the other hand, the cows produce more profit because they have already paid off their rearing costs.

Routine Principals for the Preparation of Rations and Nutritional Regimes
Dealing with nutrition on a daily basis, including the order in which the different materials are added to the mixer wagon, mixing time, the frequency at which food is delivered/pushed up again, the order in which the different rations are prepared and even the route taken by the mixer wagon between the feeding troughs — all affect the final product more than the planning of the ration and the selection of the raw materials.

Under proper management, everything that enters or leaves the feed center is weighed and mixer wagons are stationed on weigh bridges providing the operator with exact information about the quantities entering and leaving. On many farms, the mixer wagon is equipped with weighing cells and a computer that receives execution orders from the farm’s main computer; it transfers the figures on actual execution back to the computer for data processing via the same route.

The mixer wagons at our disposal are vital tools for the execution of nutrition regimes in the best possible manner. However, in most wagons a small quantity of food remains on the wagon floor after unloading. In view of the fact that this happens and the fact that food is delivered to the dry cows after the milking cows and/or the calves, the result is that in practice, the ration delivered is not exactly the same as the planned ration. The consequences are soon visible as edema, milk fever and other problems than cannot be explained by the planned ration, which in actual fact was different from the ration delivered to the cattle.

It sometimes happens, particularly when the mixer wagon has seen better days, that cattle fed from the front of the wagon receive a ration rich in grain, while the cows fed from the back end get much more fiber, hay, etc. Meticulously ensuring mix uniformity and when duly considered and justifiable, changes to the route and order in which the wagon is discharged can help create balance and solve problems which are often insoluble from the planned ration data.

We have found that the transition to an area feeding center, which will be discussed later, together with the introduction of another feed delivery tool between the mixer wagon and the dairy farm, increases ration uniformity. The additional tool is the truck or special wagon, which does not mix itself and merely transports and unloads the mix, while maintaining its original composition.

Mixing uniformity can be achieved by strict adherence to a fixed and logical order for the loading of the different feedstuffs into the mixer wagon. We will always load the dry materials (grains, concentrates, etc.) first, followed by liquid materials such as molasses, various hays,
silages and last of all, high moisture supplementary materials such as citrus peels, beer brewing wastes, etc. When alfalfa hay is available, it is worthwhile considering loading it after the silage components because alfalfa hay tends to disintegrate and often reaches an undesirable, overly chopped state if mixed for too long.

Mixing time must be pre-planned and needs to be exact because too much or too little mixing will deliver the feeding trough something entirely different to that planned.

Food remnants are a painful issue. When large quantities of food remnants are not removed and the feeding troughs not cleaned properly, fermenting and rotting materials accumulate and cause rapid spoilage in the fresh food. Under certain conditions, food remnants can be used as an excellent food for both male and female calves. When feeding calves this way, it is even more important to be careful because that type of management system can very easily cause harm to calf development. It will be ever more difficult to balance the calf ration when each day brings a different quantity of food with an unknown composition. A system that leaves no surplus food will save large sums on the cost of food, but that will only be true if the feeding trough is empty, timed for when most of the cows are lying down chewing their cud and only on condition that there will always be freely available food when the cows leave the milking parlor. If there is no food in the trough after milking, cow will lie down while the teat canal is still open, which increases risk of mastitis. Food in the trough after milking not only increases food consumption; it helps maintain udder health. Remember the importance of water trough location being at a convenient position and along the route taken from the milking parlor to the barn which will allow the cows to drink on their way from the parlor to the feeding trough.

A morning tour of the feed center, cleaning up moldy food and even food that has only slightly heated up, can prevent any number of problems.

The Principles of How to Relate to Raw Materials – Quality, Use and Flow

There are no substitutes for quality control of raw materials, correct policy and planning, but all that might prove inadequate if the mixer wagon operator and the person who must push up the food fail to do their job properly.

An incident, years ago taught me a great deal. I received a complaint about a drop in milk yield at one of the best dairy farms in the area where I was working. We began investigating the possible causes, which continued until we saw the last invoice for the delivery of soy. We discovered that the truck bringing the last load to the farm weighed less than usual amount. A quick check revealed that there had been a general clean out of the storage bins at the soya plant and therefore, the farm had received hulls with less weight and more volume than the cake usually delivered. Evidently, the employee responsible for feeding did not have the tools required for minimal quality control and the prevention of the problem. We found a rather elegant on-farm solution. We weighed a can with a known volume. Afterwards, sample was taken from every sponsored by the Israeli dairy School
load. If the sample in the can has a different weight, the operator will have a reference point to refer and prevent the recurrence of the problem.

Managing a feed center is an enormously complicated task with onerous responsibilities. It includes purchasing the materials from an accurate understanding of the marketplace and managing stock levels in a manner ensuring that frequent and unpredictable changes to the ration are unnecessary. Large farms and/or feed centers can never buy enough raw materials (principally silage and hay) grown in the same area and conditions. Changes can and will continue to be made to the rations, even on rainy days when water remains in the mixer wagon and/or when because of the rain, the silage delivered to the cows has much higher moisture content. Consequently, there may be great differences between the silages which will force great differences between the rations. Sometimes, this occurs without anyone noticing the significant differences in ration composition from day to day. Constant quality control must cover food composition, texture, smell, mold; for silages, special emphasis on the comparison between the level of dry matter in the food included in the ration and the data used by the nutritionist to calculate ration composition. Beyond this, there is an entire range of professional issues: Supervision of waste, careful purchasing of materials and awareness that not everything cheap will cheapen or make nutrition more efficient

Problems can also occur when feed center operators have inadequate skills and/or professionalism. Not all problems are caused by a technological failure or bad food. Feed center employees may have no understanding of the most basic terminology such as references to the quantity of food in a dry or fresh material.

Example: A farm that had been feeding beer brewing waste for a considerable length of time does not receive its regular shipment. The farm received a recommendation to replace one ton of dry matter beer waste with a similar quantity of concentrates. In fact, forgetting that one material contains 25% dry matter and the other 88% dry matter, the farm replaced one ton of fresh beer brewing waste with one ton of concentrates. Another farm correctly replace one ton of beer brewing wastes with 300kg of concentrates, but found itself “lacking volume” and supplemented the ration with another 700kg of silage and the results were as we might expect.

Operating a feed center using a mixer wagon hitched to a tractor, but without a silage cutter, might give different, less accurate results than when operating a similar feed center using a silage cutter and/or a self-propelled wagon fitted with a cutter.

Each manufacturer’s feeding equipment has a different mixing configuration. There are three mixing methods: Horizontal, vertical and the paddle mixing system manufactured by the Keenan Company. The type of mixing influences the character and quantity of food remnants retained in the wagon after discharge. Horizontal mixers leave food behind in the bottom of the wagon and vertical mixers leave food remaining on the knife wings. Both these types of mixer have the ability to chop the food, which is a factor that must be taken into account during mixing. Paddle
mixers are more suited to non-chopped materials such as fresh grass than to other materials. Any discussion of the practical aspects of TMR feeding must take these differences into account because their influence on nutrition implementation is often far greater than all the chemical and computer wisdom available.

Even the most carefully managed nutrition system can fail if not all the cows have easy access to the food during delivery exit from the parlor. I have visited one robotic dairy farm that reached the conclusion that not all the cows will be together at the feeding trough because at every stage throughout the day some are being milked, some are lying down and only some are eating. Therefore, there was no need for space for all the cows at once and they could save money. The consequences were very soon clear to both the farm and the planners. Cows, even when milked at different times by the robot, always want to reach the feeding trough as the feed is delivered. Crowding and competition worked to the disadvantage of the less dominant cows and the overall yield at the farm. Feeding areas, as mentioned before, clean water troughs in plentiful numbers are essential ingredients for dairy success.

Regional or Local Feed Center?
On Israeli farms, as is true around the world, management of the supply of food has undergone a number of major changes over recent decades. In the not too distant past, each farm had a forage man and it was easy to find shovels, forks and scythes on every farm. The raw materials were bought separately and mixed on site. The mixture was prepared manually and a fistful of something rarely weighed would be incorporated using a shovel to produce a mixture that would then be delivered to the cows in an un-weighed bucket or can. As time went by, central feed centers were constructed and a new, quite successful method was developed. Each farm ordered in from the feed center, exactly which feed was most appropriate specifically for that farm. Farms learned to make the transition from individual to group feeding that works for the long term.

On some farms, it was customary to mark the cows using different colors and give each cow her ration of concentrates in accordance with her milk yield. We have learned that feeding according to yield, with its constant changes has a very detrimental effect on persistence. Mixer wagons were purchased and the feeding method was changed to work with a TMR. The transition to TMR was particularly difficult for the older herdsmen because “how can it be possible that we don’t have to supplement the ration for high yielding cows”. The need for greater expertise and professionalism, together with the high cost of equipment, the seizure of land around the dairy farm for the growing of “more profitable” crops caused and are still the cause for the steady transition from the on-site, local feed center to the commercial feed center serving an area, using industrial scale food preparation technologies.

In Israel, small family farms milking 30 – 100 cows preceded the kibbutz dairy farms milking 300 – 800 head in the establishment of regional feed centers, mainly because of the cost of
machinery, manpower problem and the opportunity to receive centrally, that information which had before been in the hands of only a small number of farms.

Technological progress at the feed centers contributed much to the computerized, pre-determined assignment of mixing times and increased the ability to include small quantities of feedstuffs with short shelf life. Another step forward was the introduction of trucks to transport the mixture from the feed center to the farm, where it could deliver the feed directly into the trough. The farm receives a uniform, monitored ration and the individual farm or group of farms retains the option to choose exactly which ingredients are included.

Today, food for large numbers of cows is prepared by a relatively small amount of equipment. During this stage, most farms will benefit from great improvements and much higher accuracy in the preparation and delivery of the different mixtures. It is easy for a few (good) nutritionists to serve large numbers of farms and implement quality controls at far higher standards than was possible in the past.

Who might still gain an advantage by running an on-site feed center? Only those farmers with well designed and well maintained equipment, a fixed, professional team and the size of herd big enough to use the entire range of available raw materials with negligible waste. Those farms with a relative advantage in the supply of various supplementary foods might also find it advantageous to maintain their independence.

Most farms, many of which were suffering from equipment and manpower problems asked themselves this question when they went through the transition from an on-site to an area feed center; most have seen considerable improvements in their professional and economic results. Those who have not yet converted should examine the issue very closely to prevent unnecessary replacement of expensive equipment, which is no longer needed. The new situation might well provide them with much more quality time for nurturing and caring for the herd, which is where the profit (or loss) resides.

The Influence of Management on the Dairy Farm’s Results.

*During the first years of my work as an agricultural advisor, I visited a farm complaining about low yields, without on the surface, any negative findings in the food or anywhere else. Young and enthusiastic, I searched for a nutrition based solution but I could not find one. Wandering around the yard and conversations with the staff lead me to believe that not everything was flowing smoothly in the management of the team work and it was a problem with a decisive effect on the cows and their milk production. After a discussion and reaching the conclusion that there was no chance of changing team behavior, I acted in direct contravention of accepted logic and suggested a transition to milking twice a day instead of three times a day. Almost immediately, there were improvements across the board for all milking cows – milk composition, fertility and health. It was only several years later and after the entire team had been replaced that the farm returned to milking three times a day and the results improved appropriately. I learned that even*
though the number of milking is a matter of undeniable importance, the sought after and expected results will not be achieved if the work is not organized properly or if the correct nutrition regime is not in place.

At a different farm in a different area, I heard complaints about yields compared to other farms in immediate vicinity. A tour of the farm revealed almost immediately that there was a serious problem with the cows’ living conditions and therefore, it was difficult for the cows to meet their production potential. We offered a magic solution: A lower quality, cheaper ration. The miracle cure worked – the drop in yields was halted and the farm saved a great deal of money. Was it the right solution? Not usually! But under those conditions, it worked.

Correct planning of the ration, good milking and comfortable lying areas, combined with high quality food with the required additives are factors that influence food consumption and production. Much has been said about the links between cow weight, yield, climate and food composition on food consumption; all of these factors will fail if the cows are improperly managed.

Adult cows’ and 1st parity food consumption changes as the lactation progresses. Cows’ food consumption rises rapidly followed by a decrease after reaching the peak. In contrast, the 1st parity food consumption rises slower but stays high for longer and as they approach drying off, they eat even more than the mature cows.

Another reported finding is that there is a rise of about 17% in saliva secretion, which creates improved conditions for microbial activity in the rumen when the cow eats with her head lowered.

Sometimes, managers of dairy farms will be concerned with a drop in production (and will assume a nutrition problem). Nothing will be wrong with the food, and the cows were healthy… but a fertility problem in the previous year has caused the herd to reach an average of about 250 days from calving. Was there a nutrition problem? No. But it is important to note that a standard herd, with cows calving at times evenly distributed throughout the year, will always be at an average of 170 – 180 days from calving. The typical milk slope shows an average fall of between 0.07 – 0.08 liter / day and therefore, daily milk yield at 180 days will be 5 – 6 liters higher than at 250 days. Low fertility and poor calving date distribution will have an adverse effect on feed efficiency and overall farm results. Heifers have greater persistence and their milk yield drops at 0.05 – 0.06 liter / day.

Calving regime, cow comfort in the given living area, access to food and water, minimum disturbance during rest periods and the execution of all work in the yard or barn when the cows are away being milked, are factors with considerable influence on farm results, even before taking into consideration other factors such as climate, cooling, genetics, and ration composition, all of which are individually, issues of the greatest importance. Designated food additives such as zinc and biotin can also help and should be considered when necessary.
In hot countries, such as in Israel and even in countries in Eastern Europe the cows find it very difficult to meet the demands of production. Everyone wants to increase summer yields – The processing plant because it needs fresh milk and the producer because the price per liter is slightly higher in summer than in winter. In nature, the cow has her own timetable, which includes calving and conceiving during a more comfortable season.

Organizing summer milk production begins with the planning of calving dates. In the northern hemisphere, the best calving dates are in the spring (March – May) for heifers, which is difficult it is to organize without detriment to the normal development of calves; it is even more difficult when the cows are mature.

To increase yields, the various proposals include milking four times a day and even six times a day at the beginning of the lactation, etc. Such proposals are reasonable only if all the other necessary conditions can be met, even without higher frequency milking. The most important of those associated conditions is the quality of the forage provided. If the farmer cut the forage (both hay and silage) at the optimal time, compacted and sealed the pit properly, added the preservatives as necessary and cuts the pit face in a way that prevents secondary spoilage, he is on the right road towards a rise in yields that can be maintained high.

Researchers, advisors and stockmen working in hot climates occasionally mention the term: “summer feeding”. In truth, there is no such thing as “summer feeding”, and the required optimum is the same throughout all the seasons in the year. However, it is true that when there is a limited stock of high fiber, high quality, easily digestible roughage, it will be preferable to set it aside for use in the summer, when food consumption problems are more acute.

After ensuring a good supply of high quality forage quality it is important to make sure that the cow has a good living environment, measured in terms of a clean, dry, well ventilated and cooled lying area. The available space must be 20 – 25 square meters of roofed over yard per cow, with slopes in the lying area (cows prefer to lie on sloping ground). To reduce heat stress, adequate ventilation vents in a high roof and/or forced ventilation in the barns, next to the feeding trough and in the parlor holding pen.

When building tie stalls, be concerned about foot problems and lameness. Rubber mats over the concrete base and wide walkways increase cow mobility.

New barns and yards are not built every day, but if possible, it is important to consider the direction of the prevailing wind, which should come from the broad side of the structure and the prevent the blocking of the natural flow of the wind. Plenty of water must be readily available – with a water trough at least one meter of length for every five cows.
Do not increase the number of daily milking, if food consumption does not rise. Food consumption will rise when special attention is given to food quality and living conditions. One should not improve at the expense of the other and both must be constantly be maintained.

Planning the ration for maximum rumen functioning will have a positive influence not only on cow health and milk yield; it will also affect milk composition. The correct proportion of fiber in the food, together with buffers for balance and support, will have a positive effect on milk fat levels. Careful attention to the supply of available energy for the formation of maximum microbial protein, together with efficient, balanced, supplementary residual protein will make a very positive contribution towards protein levels in the milk.
The Principles of Ration Planning for the Dairy Herd

A colleague at work once explained to me why it was not a good idea to give the cow the opportunity to choose between two different foods, and why we should not deliver different foods to different parts of the feeding trough as is common practice on many farms. All the different components in the ration must be mixed together into a single, complete unit – the TMR. The TMR provides us with the best way to control fermentation in the rumen. My colleague added: “Cows do have big heads, but I am smarter”. The optimum ration ensures that we will achieve the best possible results.

The mixed ration commonly used on most advanced dairy farms around the world has a number of names; it is a TMR (Total Mixed Ration) in the USA, a CD (Complete Diet) in the UK and a Unified in Italy. When using this method, all the different components and ingredients in the ration are mixed together into a single unit which is delivered to the cows for free feeding. The guiding principle is based on our knowledge of the animals’ needs, our understanding of the various foodstuffs and our awareness of the links between ration composition and ingredients, the animals and the lactation stage’s influence on food consumption.

For example: At the feeding trough, cows in milk consume a daily quantity of between 18 kg and 28 kg of dry matter. If we provide a ration containing 1.76 mega calories/kg of net energy, by eating 18 kg of dry matter, the cow will consume 31.68 mega calories and a cow eating 28 kg of dry matter daily will consume 49.28 mega calories.

Two basic assumptions:

- As supported by measurements, the common assumption is that cows at the end of their lactation consume 18kg of dry matter daily. At that stage, the cows need some 13 mega calories for body maintenance and weight gain. Therefore, they are left with some 18.68 mega calories, which is sufficient energy to produce 22kg – 25kg of milk with an energetic value of about 0.75 mega calories, due to the high fat levels in the milk at this stage in the lactation, with something left over for weight gain.
- At their peak production levels, cows can reach a daily consumption of 30kg – 33kg dry matter per day. Therefore, the proposed ration provides them with 52 – 58 mega calories of net energy per day at that stage. After subtracting 11 mega calories required for maintenance, the cow is left with enough energy to produce 55kg – 65kg of milk (with an average energetic value of 0.65 – 0.79 mega calories per liter). Perhaps even more will be produced, because an improvement can be expected in food efficiency – as yield rises, the body maintenance component shrinks relative to the whole and the level of escape protein rises.

The examples given above and the management knowledge acquired shows that it is possible to supply very conveniently in a single ration the energy needs for 90% of the cattle. Yield from the
lowest 10% will be below the threshold for economic viability and so they will be culled from the herd.

Chapter 21 explained a different management method, which employs three different mixtures for the entire herd. One is for cows after calving, the second is for high potential cows in milk and the third is for low potential cows. Whereas the rations are different, the management system is unified and there is no transfer of cows from one system to another in the middle of the lactation. Groups of 1st parity receive the same ration as the high potential cows and are kept in a separate pen.

In order to achieve the required results, ration planning must follow a logical sequence:

1. Define the objective: **Maximum yield or maximum efficiency**.
2. **Make an assessment of the available local and laboratory data for the feeds** in the planning matrix. Preferably, data will be sourced from a single laboratory in order to get identical, repeatable results.*
   * regrettably, despite the fact that all the laboratories work according to the same templates, the results are insufficiently uniform for our purposes.
3. After completion of the first two stages, **Define the demands for feeds and food composition**.
4. **Make adjustments to the planned ration** by examining its efficiency when consumed by the animals.

To ensure the success of this work, it is essential to institutionalize the daily monitoring of feeds consumption data. Changes to the ration shall be made as infrequently as possible and then only if there are changes to food dry matter composition or to cow performance. Most important, always believe in the cows and learn from them. Make decisions based on the cows’ reactions.

**Note:** All laboratory tests must be done according to the official AOAC because good comparison requires accuracy. Sample collection and preparation (grinding, temperature, etc.) for the laboratory test have a great effect on the result.

The Optimal Ration Composition per Kilogram of Dry Matter **:**

- **Protein**: 16.5% - 16.8%, with equal proportions of survive, degradable and soluble protein. During the short period between calving and the third week of lactation, a temporary regime can include a rise to 18% - 18.5% protein.
- **Fat**: 4% - 5% (when rations have a high proportion of roughage and protected fats are supplied, it is possible to raise the upper limit to 6% - 7% of the ration dry matter).
- **Cell wall level**: 28% - 35% of the ration, but the decision depends on production objectives (higher level when seeking a high level of fat percentage and a lower level when the objective is to maximize fluid production).
- **Roughage NDF** will reach 17% - 21% of the diet dry matter, depending on the source of the roughage and its physical structure for the purposes of rumen filling, regurgitation of
cud and saliva excretion. (Finely chopped maize silage will have a high value and a ration containing a high proportion of long fiber cereal hay will have a low value.) In extreme circumstances, when the roughage is whole straw, the lower limit can be even less, reaching 13% - 14%.

- Starch**: 30%, but it is essential that the starch should be sourced from a variety of grains because each grain starch breaks down differently in the rumen. (Starch breakdown rate from high to low: Rye, wheat, barley, oats, maize, sorghum.) When the farmer is not in possession of starch value data, starchy foods can be defined as “grains”. Israeli experience shows that a level of 35% grains is sufficient for a balanced ration, on condition that there is a range of grains with different breakdown rates. Grain levels can be lower when the ration contains a high proportion of first class roughage high in digestible fiber. As we don’t have good laboratory technique for starch evaluation, "grain" system was establish as an alternative tool for diet formulation knowing that an average cereal grain contain about 60% starch.

- Pectin: 5% (pectin is the substance that glues the plant cells together. It is present at high levels in foods such as citrus peels and it has high energetic value).

- Sugar – 5%
- Ash (minerals and the natural ash in the food) 4% - 5%

* Most researchers agree that rations with a high level of protein (18% and above) have a negative influence on nutrition efficiency and the supply of energy to the cattle (see Chapter 5.2). However, there are many farmers, perhaps too many, not making proper use of the considerable amount of knowledge of this subject in the research. Regrettably, they provide excessive amounts of protein and thereby interfere with the supply of energy.

** Savings can be made on starch quantities when the farm can provide high quality food, rich in non-structured carbohydrates (NSC) such as citrus peels, beer brewing wastes, beet pulp, etc. On the other hand, a rise in free sugar levels and to a certain extent, when the pectin supplied exceeds the recommended level, can have a detrimental effect on the overall digestion of fiber and cause accelerated flow through the digestive system. In extreme cases, they can cause acidosis in the rumen. A discussion of the nature of available energy supplied by non-structured carbohydrates must take their composition into account. The NSC in maize silage comprises 71% starch and some 29% volatile fatty acids. Grass hay contains some 35% sugar, only 15% starch and almost 50% pectin. Apart from the starch, maize grain contains some 21% sugars and whereas barley grain contains only 9% sugar, it also contains about 9% pectin.

*** Strict adherence to the benchmarks given here as the basis for a balanced ration and the proportions in the ration (starch, different proteins, effective fiber, additives, etc.) is a vital factor in achieving success and nutritional efficiency.

Today, we can use computer software to characterize the different components in the diet and we can use that information to adjust the ratio of each food in the ration. We must always ensure the
inclusion of soluble protein with degradable energy designed to enable on the one hand, fermentation in the rumen and on the other, survive protein together with starch that will survive the stomach and be available to the cow when absorbed through the intestines.

<table>
<thead>
<tr>
<th>Component</th>
<th>Component Structure</th>
<th>Breakdown Level in the Rumen</th>
<th>Breakdown Rate in the Rumen (% per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>A NPN</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1 Soluble Protein</td>
<td>Rapid</td>
<td>120 - 140</td>
</tr>
<tr>
<td></td>
<td>B2 Real Protein</td>
<td>Medium</td>
<td>3 – 15</td>
</tr>
<tr>
<td></td>
<td>B3 Real Protein</td>
<td>Slow</td>
<td>0.2 – 0.5</td>
</tr>
<tr>
<td></td>
<td>C. Bound Protein</td>
<td>Does not break down</td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-structured</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>A1 Sugar, organic acids</td>
<td>Rapid</td>
<td>75 – 400</td>
</tr>
<tr>
<td></td>
<td>B1 Starch, Pectin</td>
<td>Medium</td>
<td>5 – 50</td>
</tr>
<tr>
<td>Structured</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>B2 Cellulose, Hemicellulose</td>
<td>Slow</td>
<td>3 – 15</td>
</tr>
<tr>
<td></td>
<td>C Lignin</td>
<td>Not available</td>
<td></td>
</tr>
</tbody>
</table>

Table 10: Sources of Protein and Energy – Characterization and Breakdown Rates in the Rumen

Ration Planning Management
It is standard practice in Israel to calculate the ration in values averaged for 20 kg of dry matter. The results from these calculations are expressed as a percentage of dry matter. Therefore, at the day to day working level, the language used is convenient for both the nutritionist and the team on the farm. The technique is simple – the quantity of food consumed is stated as a measurement of appetite percentage. Thus, when it is stated that the cows have eaten 120%, everyone knows that it means 24kg of dry matter (20 X 1.2 = 24). Using this method, 5% of the ration is equivalent to 1kg of dry matter, which allows us to constantly monitor actual implementation with considerable ease.
The balanced ration must have another dimension, beyond the rates for normal values. There is a reciprocal relationship between amount of protein and energy in the ration. Always maintain an even balance between survive, degradable and soluble proteins; give attention to the breakdown rate for the source of energy. If there is no simultaneous availability of energy in the rumen, degradable and soluble proteins will not provide the desired results and which will cause a loss of protein. A high level of survive protein can be detrimental to microbial activity.

Vitamins and minerals are two groups of food additives which we must never forget to add to the ration. Research on these subjects is far from comprehensive, and there is a lack of full understanding of the efficiency of these materials and the degree which they are absorbed. Therefore, the nutritionist working in the field usually includes them in the ration at levels slightly beyond those recommended in the various models; they take care to maintain a balance and do not give toxic amounts. A growing tendency to include organic minerals to augment the availability of critical substances such as zinc helps to maintain hoof and udder health. Another current trend is to raise Vitamin E levels to between 1,000 and 2,000 units per milking cow per day and 4,000 units per dry cow.

A survey by M. E. McCullough found that northerners were of the opinion that there were enough vitamins in the ration and there was no need to add more. In contrast, the southerners recommended adding a supplementary 500,000 units of Vitamin A per day per cow. Both were correct in reference to the conditions and region where they worked.

There is a wide range of food additives currently available in the marketplace and some target forage specifically. They include yeast cultures to improve food efficiency and probiotics, the efficiency and importance of which are unclear, but they are used by some farms. Other additives: Minerals and vital, limiting amino acids, treated to prevent their breakdown in the rumen, improve their availability and guarantee their supply to the cattle; toxin absorbers; antioxidant preparations (Vitamin E) to improve cattle immunity and specific preparations designed for that purpose. On a commercial farm, it is difficult, if not impossible to prove the efficiency of additives. In contrast, the literature is rich in data gathered during observational and controlled research, which obliges the nutritionist and the farmer to exercise their discretion and their abilities to analyze the research to adapt the published results to the specific conditions on each individual farm.

There are a number of anti-acid materials currently available such as sodium bicarbonate, which is a aqueous soluble, mineral buffer (Acid Buff) and a natural product, but it breaks down slowly in the rumen throughout the day, even when not adjacent to a meal. When preparing most rations, all these considerations must be taken into account because the maintenance of the correct chemical environment in the rumen is almost to care for the cow’s heart and soul. The preparation of even the most carefully balanced ration cannot always rely solely on its constituent components.
Additives do not replace a balanced ration, but cautious, careful management help to achieve the objective.
Typical Rations for a Cow in Milk
Two rations for high yielding cows in milk are given below. The principal difference between the two rations is the source and level of fiber food (roughage). Ration data is presented as a percentage of dry matter in the total ration.

Ration 1 Conditions: A lack of good quality fiber food and wheat silage as a principal component.
Ration 2 Conditions: Maize silage and legume hay as the main sources for fiber forage.

<table>
<thead>
<tr>
<th>Table 11: Typical Rations for Cows in Milk (Values are given as a % of dry matter in the total ration):</th>
<th>Ration 1</th>
<th>Ration 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley grain</td>
<td>4.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Maize grain</td>
<td>23.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Wheat grain</td>
<td>5.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Soy cake</td>
<td>6.3</td>
<td>8.1</td>
</tr>
<tr>
<td>Canola cake</td>
<td>43.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Whole crop wheat hay</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Wheat silage</td>
<td>25.7</td>
<td>---</td>
</tr>
<tr>
<td>Maize silage</td>
<td>---</td>
<td>24.2</td>
</tr>
<tr>
<td>Calcium additive</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Protected fat</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Vitamin and yeast concentrate **</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Salt</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Citrus peels</td>
<td>3.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Gluten feed</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Legume hay</td>
<td>2.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Molasses</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>DDGS</td>
<td>5.5</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Ration Contents**

<table>
<thead>
<tr>
<th></th>
<th>Ration 1</th>
<th>Ration 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein percentage</td>
<td>16.6</td>
<td>16.6</td>
</tr>
<tr>
<td>Net concentration of A for milk</td>
<td>1.77</td>
<td>1.77</td>
</tr>
<tr>
<td>Percentage of roughage</td>
<td>31.2</td>
<td>38.2</td>
</tr>
<tr>
<td>Total cell wall</td>
<td>29.6</td>
<td>30.5</td>
</tr>
<tr>
<td>Cell wall from roughage</td>
<td>17.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Fat</td>
<td>5.0</td>
<td>5.1</td>
</tr>
<tr>
<td>“Grains” ***</td>
<td>32.9</td>
<td>29.5</td>
</tr>
</tbody>
</table>

* One of the important principles when planning a ration is the variety, which can often compensate for our lack of knowledge.
** Example of the standard composition for a minerals and vitamins concentrate for cows in milk and dry cows:

<table>
<thead>
<tr>
<th></th>
<th>In Milk</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A iu</td>
<td>10,000,000</td>
<td>10,000,000</td>
</tr>
<tr>
<td>Vitamin E iu</td>
<td>2,500,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Vitamin E iu</td>
<td>200,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Manganese in grams</td>
<td>30</td>
<td>2.10</td>
</tr>
<tr>
<td>Iron in grams</td>
<td>20</td>
<td>0.44</td>
</tr>
<tr>
<td>Copper in grams</td>
<td>15</td>
<td>4.2</td>
</tr>
<tr>
<td>Iodine in grams</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>Selenium in grams</td>
<td>0.3</td>
<td>0.04</td>
</tr>
<tr>
<td>Zinc in grams</td>
<td>30.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Vitamin B3 (niacin)</td>
<td>---</td>
<td>60.0</td>
</tr>
<tr>
<td>Yeast culture in grams</td>
<td>---</td>
<td>300.0</td>
</tr>
<tr>
<td><strong>Per head in grams</strong></td>
<td><strong>20.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The concentrated mixture explained here is an example of a standard product in use in Israel and adapted to suit local knowledge and experience. As is true for many other issues, the problem is that there is a wide range of data available in the various dosage tables in the professional literature, but there is not enough information about each mineral’s availability, absorption and efficacy, or the reciprocal relationships between the various groups.

*** In a ration based on maize silage some of the silage will be calculated as a supplier of “grains”.

The rations presented here emphasize the differences in ration composition as dictated by the source of the fiber food at our disposal. Furthermore, one of the most important principles in ration planning for cows in milk is variety: Variety in the sources of protein, and variety in the sources of energy and fiber. Variety creates a situation in which a lack (even if we were unaware of its existence in a particular food) will be compensated for by its presence in a different food. **The final result might give us a strange mathematical result: 1 + 1 > 2.**
Dairy Farming Profit and Loss

As is true for many other farming industries, dairy farming is not one dimensional. Rearing calves, nutrition policy, forage quality, cattle health, living conditions, use of materials, range of services, etc. are all part of the package. That plus the government’s economic policies affect the final result. As a supplementary list, we can also add equipment quality and maintenance and the quality of work performed by the farmers and farm personnel.

Remember that no one is perfect and there is always room for improvement, even in the most successful dairy herd.

Discussion of food issues will always include the food itself, sources of food, food content, and food prices. Most importantly, we must look at total food cost, which is the sum of all the factors contributing towards the final result and in dairy farm terms – food efficiency.

Whether the food is expensive or cheap is not necessarily the factor with the greatest influence on the final result because only the correct combination of all the relevant factors will determine success or failure.

Work policies, the links between nutrition management and living conditions, etc., the use and costs of materials and services, interest and working capital are all weighty issues, each of which must be discussed separately before their inclusion in the final mosaic.

When the more expensive foods, such as young grass or wheat silage cut at the beginning of the grain filling stage, are included correctly into the ration, they can improve food efficiency, reduce overall food costs and they expand the gap between income and expenditure per cow. To achieve this, the wise men tell us: “only the rich man can afford to buy cheap” or, (more practically): “Price (size) doesn’t matter”.

The type of forage, ground or rolled grains, sources of protein with varying quality and price, additives and unusual foodstuffs, which when used can contribute to environmental quality, are factors in a complex system that must be viewed as a whole.

Two examples of the intelligent use of available foodstuffs:

- Compare the use of “expensive” soy containing some 50% protein with “cheap” DDG with a much lower protein percentage. Lysine is a limiting, vital amino acid, which constitutes some 13.5% of the soy protein and only 3.8% of the DDG protein. In soy, 28% of the protein is surviving protein, almost all of which is absorbed in the intestine. In contrast, DDG has a much higher percentage of escape protein, which on the surface, should be even better, but it has been found that up to some 20% of that escape protein, is bound and exits in the feces in exactly the same form that it entered through the animal’s mouth.
• Maize grains (course ground) help provide energy directly available to the cow through the intestines for the benefit of the energy balance, fertility and perhaps also for milk protein. In contrast, other grains such as rye and wheat contribute a much higher percentage of starch in the rumen and they are vital for the supply of energy for microbial populations in the rumen. Therefore, the “correct” ration must always contain a variety of grains and not just one grain variety, even if it is the cheapest.

In reference to the range of nutrients in the ration (energy, protein, etc.), there would appear to be only one optimal solution (Chapter 22.1), which is a function of the production target. Any deviation from that solution will be detrimental to nutrition efficiency. Alternatively, successful balancing of the ration does not necessarily result in the sought after financial success.

The examples given here are the appropriate action to be taken by a reasonable dairy farmer. However, when there is a lack and/or excess of energy and/or other nutrients, solutions must be found through the re-examination of the feeding regime, forage quality and the manner in which the ration is prepared – not in ration composition as it appears on the computer printout.

We know that each cow can be different from the cow standing alongside it at the feeding trough. Even if the group is receiving the optimal, well balanced ration, some cows in the group will respond in terms of yield and good fertility, while others will react by putting on weight. That is why breeding and selection are important. Equality does not exist in a herd.

The calculated price for the ration will always take into account the market or local price for all the foodstuffs in the quantities included in the ration.

The calculated cost for the ration is a combination of the price and actual consumption, to which we must add the effects of management system and wastage levels.

Food supplied is not a stand-alone factor – many other factors influence farm results. If a structure needs constant maintenance and bedding, production costs and wages will be higher. Inadequate housing is often the source of disease and can determine a less than optimal milking regime.

Rest days and dry period management systems, lactation length, fertility, veterinarian costs are all integrally linked to housing, feed and water systems and nutrition policy. An analysis of farm must examine each segment separately to ensure that the total effect to be optimal. Some farms do an excellent job in terms of nutrition; some work well with few people and buy services at low cost. The overall direction must maintain quality in every field. The overall result given as a summary may be satisfactory – but that is not good enough. Every stage and type of work must be analyzed and considered.
Table 12 provides a comparison between three Israeli farms. All three have relatively good overall financial results, but on each farm, the success was due to a different field within dairy farm life and all that despite the differences between farm size and food costs.

<table>
<thead>
<tr>
<th></th>
<th>Farm A</th>
<th>Farm B</th>
<th>Farm C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Milk Production per Cow in Kg.</td>
<td>14,000</td>
<td>8,890</td>
<td>11,700</td>
</tr>
<tr>
<td>Total Annual Herd Yield in Kg.</td>
<td>2,800,000</td>
<td>2,800,000</td>
<td>5,500,000</td>
</tr>
<tr>
<td>Number of Cows in the Herd</td>
<td>200</td>
<td>315</td>
<td>470</td>
</tr>
<tr>
<td>Fat Percentage</td>
<td>3.70</td>
<td>3.77</td>
<td>3.70</td>
</tr>
<tr>
<td>Protein Percentage</td>
<td>3.30</td>
<td>3.34</td>
<td>3.38</td>
</tr>
<tr>
<td>Income per Cow (in NIS)</td>
<td>26,500</td>
<td>18,500</td>
<td>22,000</td>
</tr>
<tr>
<td>Feed Costs per Cow (in NIS)</td>
<td>10,500</td>
<td>7,400</td>
<td>10,500</td>
</tr>
<tr>
<td>Operating Surplus Per Cow (in NIS)</td>
<td>11,000</td>
<td>7,750</td>
<td>8,200</td>
</tr>
<tr>
<td>Kg. Dry Matter per Liter of Milk (in NIS)</td>
<td>0.65</td>
<td>0.81</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Table 12: Comparison of Three Farms’ Results for 2006 *

* Figures rounded up

** Food was supplied by a regional feed center and work making up the feed is included in the price.

Analysis of Nutrient Costs

<table>
<thead>
<tr>
<th></th>
<th>Farm A</th>
<th>Farm B</th>
<th>Farm C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Milk Production per Cow in Kg.</td>
<td>14,000</td>
<td>8,890</td>
<td>11,700 *</td>
</tr>
<tr>
<td>Cost of 1kg of Dry Matter in the Ration (NIS)</td>
<td>0.985</td>
<td>0.885</td>
<td>1.04</td>
</tr>
<tr>
<td>Dry matter digested to produce one liter of milk</td>
<td>0.65</td>
<td>0.81</td>
<td>0.76</td>
</tr>
<tr>
<td>Food costs to produce one liter of milk (NIS)</td>
<td>0.64</td>
<td>0.717</td>
<td>0.79</td>
</tr>
<tr>
<td>Income per liter (NIS)</td>
<td>1.73</td>
<td>1.74</td>
<td>1.78</td>
</tr>
<tr>
<td>Food Costs / Milk as a %</td>
<td>37</td>
<td>41.2</td>
<td>44</td>
</tr>
<tr>
<td>Total income per liter</td>
<td>1.94</td>
<td>1.97</td>
<td>1.97</td>
</tr>
<tr>
<td>Total costs per liter</td>
<td>0.77</td>
<td>0.79</td>
<td>0.94</td>
</tr>
<tr>
<td>Food / yield as a %</td>
<td>40</td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td>Work per liter (NIS)</td>
<td>0.25</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Difference in total return ** food / liter (NIS)</td>
<td>1.17</td>
<td>1.18</td>
<td>1.03</td>
</tr>
</tbody>
</table>

* Food supplied by an regional feed center and therefore food costs are higher than the others and include operating costs (work and equipment) for the preparation and delivery of the food to the troughs.

** Includes income from meat and calf rearing

sponsored by the Israeli dairy School
If we compare the results from Farm A and Farm B, which produce the same quantity of milk from different sized herds, we realize that notwithstanding the large difference in feed costs (much higher on Farm A), Farm A has a clear advantage in milk yield and feed costs per yield. Farm B uses lower cost foodstuffs and to reach the same overall level of production must have a much larger herd. A far greater proportion of Farm B’s income is derived from the sale of meat. Other contributing factors are the low cost ration, low levels of food consumption and savings on work, which would seem to be due to herd size. Farm B’s figures could be problematic for a herd based solely on milk production, because during 2006, meat prices in Israel were much higher than average and those prices cannot be relied upon for the long term.

Farm C’s results show comparative advantages in most activities, which brings us to ask questions about feeding policies at the feed center. It would seem that if the nutrition regime used by Farm A would be applied at Farm C, the results would be a lot better, and that is the real challenge for us all.

It is reasonable to assume that if Farm A had a larger production quota, its work efficiency would improve and that is also true for its income per liter, even to the point that Farm A could achieve better results than Farm B. Regrettably, it is often true that there is no link between nutrition planning, nutrition policy and nutrition execution. The economic analysis must be able to isolate each different factor. It is pointless to make bland statements, which contribute nothing to the understanding of the results, such as: “there is no connection between yield and profitability”. Each individual farm must adjust nutrition policy and nutrition composition to its execution capabilities and conditions. That seems to be the reason for Farm B’s achievements, even though it would seem that by making relatively small changes, Farm B could realize its potential for further, considerable improvements.

The three farms examined are significantly different in terms of size, available structures and staff. Therefore, the comparison made here might be misleading, if we do not analyze their results from the overall perspective of each individual circumstance.

You may ask why, for so many years, Michael Schumacher was the world’s fastest driver in a Ferrari. All the competing drivers had similar cars, fuel and they drove the same tracks. It seems that the difference lies in the individual man. On the farm that means skills and zeal, paying close attention to details, large and small. It means also paying close attention to the management system, structures, inseminations and milking.
Manure and Other Excretions

The average milk cow excretes some 10kg of dry matter in its urine and manure every day. Manure can be a valuable commodity as a fertilizer. As manure breaks down, it can be used as a source of energy. It can even be used for cooking and heating.

An average cow excretes some 20 tons of manure (feces and urine) each year, which contains some 200kg nitrogen, 40kg phosphorus and some 70kg of potassium. If not applied and incorporated close to actual excretion, most of the nitrogen in the urine becomes volatile ammonia over time. However, proper use of excretions as fertilizer will contribute towards higher crop yields and improved soil structure. It prevents environmental pollution and will reduce the need for chemical fertilizers; the manufacturing causing a great deal of air pollution. Furthermore, chemical fertilizers are often applied in excess or in a manner which leads to flushing and pollution of the ground water.

Modern dairy farms often get more caught up in the business of manure removal then cattle nutrition. Solid manure removed from lying areas can be transported directly to fields. Liquid manures from the parlor holding pens and walkways are more difficult to handle, but with proper organization and timing they can be spread on fields immediately after their collection in on-farm storage facilities. Planning a dairy farm must take into account manure management along with local topography, climate and cow comfort. Farms with tie stalls must remove manure every day, while wide, free yards providing each cow with 25 – 30 shade square meters per head can even allow liquids to penetrate the bedding. Proper treatment, which includes cultivating and leveling the bedding, can almost entirely eliminate the problem.
Organizing Work on the Dairy Farm

19th Century dairy farms had just a few cows and were very small scale, family businesses. The farmer and his partner did everything. The modern dairy farm can have 100, 1,000 or even 10,000 cows and it is an industrialized process necessitating organization and order. The farm manager must have a broad view of all the different sub-units, from calf rearing to costing and financing. The staff must be divided up according to specific expertise – Calves, heifers, dry cows, milking cows, fertility, health, milking and overshadowing it all – economics. It is important to know how to exploit the knowledge provided by advisors on mechanization, structures, nutrition, management, health, accounts and finances.

On many occasions, efficient dairy farms lose money because records were in a mess and with no controls in place. Weighing and recording all that entering and leaving the farmyard, precise records of all bills paid, the well-organized storage of foods and spare parts are all essential on the modern farm. During the day-to-day work it is important to provide every employee with full knowledge of what is happening because a well-informed, interested employee will contribute more.

As is true for manufacturing industries, the dairy farm must develop information transfer systems. No man, however talented, can know or remember everything. I once had an opportunity to visit two electronics companies in South Wales. One company was in a building without internal walls so there was constant contact between management and the staff. The other had separate sections for each hierarchical level within the company. The former was profitable, and the latter was losing money.

The daily farm routine must be fixed and strictly adhered to. Some might prefer cleaning out the feeding troughs before milking, while others will perform the task in the afternoon. In fact, the timing is a matter of no consequence. What is important is that it is done every day at the same fixed time, set by the farm for its own convenience. Before the daily delivery of food, it is important to estimate the quantity uneaten and to adjust the ration quantity accordingly. Sometimes, only tiny changes in ration composition are necessary for the new day. Cows will be separated off for insemination and veterinary treatment using the special gate at the exit from the milking parlor. Large farms unable to use milking parlor exit gates, must do all that they possibly can to ensure that the cows are not disturbed in the lying areas. If cows are tied at the feeding stalls, such time must be kept to a minimum. Maintenance of the lying areas (electrical work, manure removal, etc.) should be executed only when the cows are not present. Preferably, even milking staff will not leave the parlor to bring a new group into the holding pen. Milking will end sooner and cow maintenance will be more efficient.

Saving work hours and/or reducing food quality are not legitimate targets. Proper organization of work, and division of responsibility at fixed times is permissible, even if it means adding another member to the team.
Nine Reasons Why a Good, Well Balanced Ration Doesn’t Always Work

The computer and the nutrition program prepared by that computer are vital tools, but it is not always understood why cows do not react to the program and the model in the manner expected of them. To characterize the possible reasons, we should check each of these factors:

1. **The heifer has reached the appropriate age, but she is still not ready.** It will be difficult to realize her potential, and there is little we can do about it.
2. **The dry period** – short or long; there was fattening up, or a drop in body condition.
3. **Cow comfort**, plenty of clean, dry, lying space, preferably on the slope; ventilation and cooling in the barn, the holding pen, with or without water troughs.
4. **Easy access to the feeding troughs** with no superfluous gates or barriers. A smooth, clean feeding trough. Delivery of food several times a day; close attention to a clean feeding trough at least once a day. Food always available in the trough and most importantly, after milking.
5. **Cool, clear water** and lots of it available in likely and unlikely places, in the yards and along the walkways to and from the milking parlor.
6. **Hygienic milking practices** and the minimum possible time spent crowded in the holding pen before milking.
7. **Fertility management**, watching for heat and correct planning of the first insemination date and lactation length. Over extended lactations can lead to cows dried off in excessively high body condition. Pregnancy too soon after calving may cause short lactations because cows are prevented from building up the reserves they need.
8. **The standard of TMR preparation**, with special emphasis on a uniform mixture, mixing time in the wagon with or without knives and fiber length according to the range of foodstuffs and their ratios in the ration.
9. **The monitoring of the quality of raw materials and moisture levels in silage and hay**, heating up in storage, the quality of grain grinding and rolling and more….**Look, be there, check and observe, but not only through the computer screen.**
Conclusion: The Cow – The Heart of the Matter!

Close attention to the cow’s comfort and needs will help us achieve both professional heights and maximum profit.

The objective, Milk yield? No. The objective for the commercial dairy farm is money in the bank; the means to achieve that was, and is – the cow, what the cow produces and its offspring.

Over the short term it is possible to achieve that objective in a variety of ways. Less investment, cheap food, the conjuncture of meat prices, etc. Over the long term, there is no alternative than to place the cow at the center.

The significance of placing the cow in the center begins with housing and continues on to the calf rearing process, food, water, genetics and the never ending input by the farmer.

Large, industrialized dairy farms have almost no dealings with the cow. They are not identified and veterinary help is minimal, but a great deal of attention is given to their food and living conditions, to ensure that the problems that must be solved simply never appear in the first place.

On a family farm, even if it has 1,000 head of cattle, producing milk under quota, every cow must be dealt with. Every one, and you must know all there is about her. We must nurture every cow in order to receive full benefit from her.

Living conditions: Cows require a clean, dry living space. In a free yard, try to provide 20-30 square meters or more of covered lying area, roofed at angles meeting at a central apex. There should be easily accessible food in the trough on one side of the yard and the water troughs will be in the shaded areas on the other side. Separating the two will ensure good distribution of the cows in the available space; it will prevent the formation of sodden pathways within the yard and will reduce crowding. Gates and barriers will be as few and far between as possible to ensure the free flow of cows around the yard – they will feel better.

Cows will be separated off for treatment only using the special separation gates at the exit from the parlor and if possible, cows should never be sorted when already in a group.

Electrical, metal and plumbing repairs will be performed only when the yard is empty of cattle. Guests and visiting vehicles will be kept at a distance. In summer, exercise every iota of knowledge and imagination (there are many examples) to keep the cow cool, with a body temperature never rising above 39º C. Whereas it is possible to cool roofs and lying areas, the most effective cooling seems to be in the parlor holding pen. In hot climates, we will begin cooling when night temperatures rise above 18º C. We will cool cows with body temperatures higher than 39º C. Cooling will be before milking, between milking and most importantly, at night. Cooling in the holding pen, including waiting for milking means that the cow will be...
standing on wet concrete for 3.5-4 hours a day. Therefore, rubber matting will be of great benefit to cow comfort, and hoof health; the results will be found in the milk tank.

Food will be fresh and clean. We will not abstain from using by-products from the food processing industries because the herd can also play its part in the clearing away the wastes to its benefit. However, we will always act with caution and discretion. Such foods must be free of mold, fungus and foreign bodies. We can pay slightly more for quality foodstuffs and rations, including additives, if we know how to check and monitor the results; primarily food efficiency and the cost of food for production. **Price (size) doesn’t matter.** It is food quality, exploitation and efficiency that are important because in so many instances, it is the “expensive” rations that cost less.

Food delivery must be timed to correspond with other types of work around the farm. There will always be food in the trough when the cows leave the milking parlor, during the cool hours and when the wind blows. We save on costs if we work without leaving food behind and by re-filling empty feeding troughs just when most of the cows are lying down, chewing their cud.

We will never cut corners when rearing calves as replacements for the herd. Saving money is important, but we will make those savings by rearing fewer calves rather than holding back the development of the replacement calves.

We will be rigorous in the implementation of insemination and rest day programs in order to avoid lactations than continue on for too long. We will talk to the cow and when she is in heat and healthy, we will bring her to the inseminator, even if only 60 days have passed since she calved. A cow showing no signs of heat shall be taken for examination according to the policy determined by each individual farm, but no later than 70 days of lactation.

Rigorous implementation of the rest days program will lead us to drying off when yield is still relatively high and the cow has not yet fattened up. That will succeed in creating an efficient life cycle with minimum calving diseases. Drying off can be shorter than the standard period, but in all circumstances, we must prevent a long drying off, with all its associated problems.

Vitamins A, E and even B (niacin) are very helpful for the dry cow, because the dry stage is the most difficult and most significant stage in the production cycle. Minerals as advised, including protected and more available minerals can only help to prevent crises. We shall do all we can to encourage food consumption and the supply of energy.

The problem that we have to deal with is always how to balance energy after calving. The simple solution lies in lactation length and preventing fattening, combined with a ration, foodstuffs and a management system that encourage food consumption. The solution is not necessarily found in computer generated solutions that raise the concentration of energy on paper.
The cow is at the heart of the matter. We will care for her body, food and comfort. In return she will ensure our comfort and our livelihood.

Finally: The Objective
To get up each morning with a smile and a desire to create is a most worthy objective. Maximizing profit in a manner that disregards victims along the way is unseemly and is therefore, an unworthy objective.

I am reminded of the wise adage: “Love thy neighbor as thyself”. To live by that adage, we must continuously learn and acquire knowledge. The comments made here open doors. All the rest is in books, of which there is no lack.
Appendix: Energy Characterization in Food Model

Total Energy (GE)
  ↓
(30% lost through the feces)
  ↓
Digested Energy (DE)
  ↓
(10% lost in the urine and as gases)
  ↓
Metabolic Energy (ME)
  ↓
(20% digestion heat losses)
  ↓
Net Energy (NE)
  ↓
Net Energy for Milk
  ↓
Net Energy for Maintenance
  ↓
Net Energy for Growth
  ↓
Energy left for production
  ↓
20% of the total energy
Appendix 2: Cow management model according to current yield potential.

Practical feeding management
(Proposal)

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>All Cows In Early Lactation</th>
<th>High potential cows</th>
<th>Lower potential cows</th>
<th>Dry period</th>
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<tr>
<td>14-21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>305-320</td>
<td></td>
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</tbody>
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Learn how the Israeli cows produce 12,000 Kg of milk a year

Introduction:
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Main topics of the seminar program:
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- High yield production under hot climate and heat stress conditions
- Breeding and fertility management
- Economic aspects of management of dairy herd
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