Calf Rearing Guide

Practical and easy to use

By S.J. Charlton



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Introduction

It is impossible to write a book covering all the areas of calf rearing. There is a lot of information available and large variation in rearing methods, breeds and environment. Successful calf rearing requires an understanding of basic principles as well as experience and observation. Profitable calf rearing requires an ability to provide and monitor the most suitable environment and feed to meet growth and rearing targets.

This Calf Rearing Guide is compiled using solid research-based concepts with the objective to encourage calf producers to easily find and understand basic principles with practical applications and evaluation.

The book format is consistent throughout to enable readers to quickly find information on key calf topics. Each section is colour coded and each topic takes a 3-step approach for quick reference. i.e.

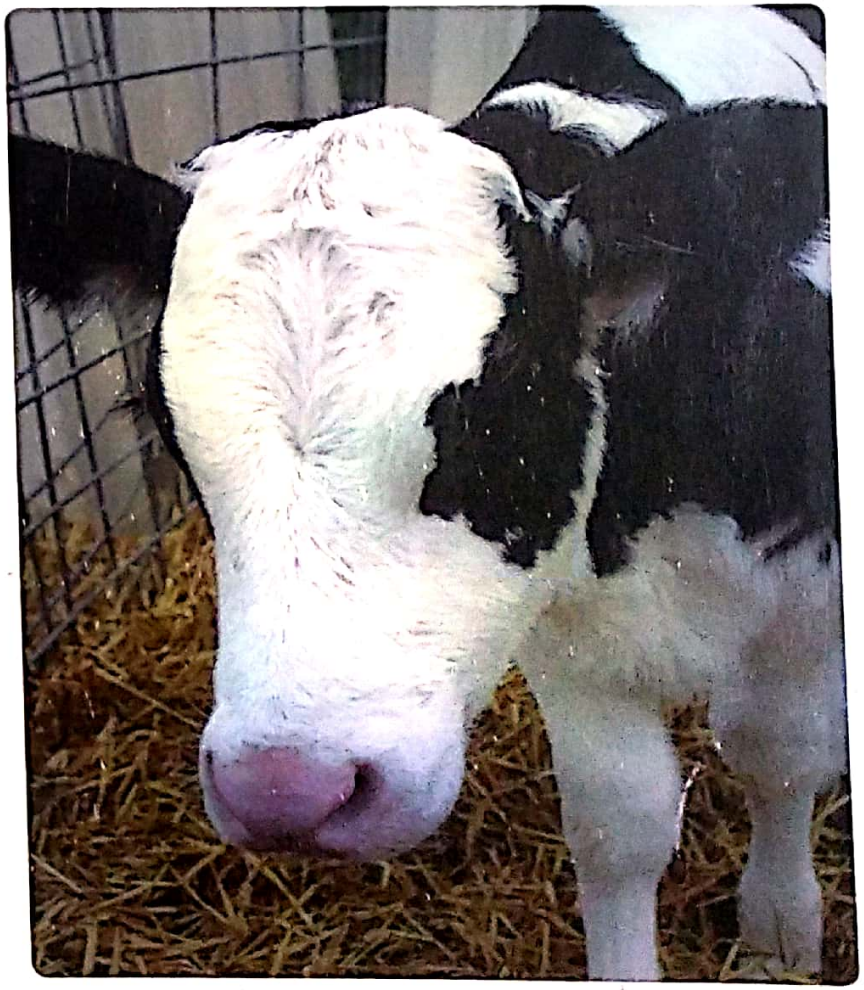
Explanation – what it is and why is it important

Application – practical applications for the producer, what, how and when

Evaluation – assessment and/or troubleshooting

This format enables the reader to quickly find relevant information on a given topic. Pictures, goals, targets, top tips and a concluding check list for each topic, add useful and quick reference points.

This easy to read guide on calf rearing from birth to weaning is ideal for producers, managers, veterinarians, advisors, students, teachers and other professionals providng an excellent reference tool or training aid for successful calf rearing.



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Section 1

Calf Rearing Guide — Practical and easy to use

Physiology

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Digestion
Explanation

Definition
The process of breaking down food (complex substances) into small, simple substances that can be absorbed into the blood and lymph for use by the body for maintenance and growth.

What is it?
There are 3 processes of digestion:

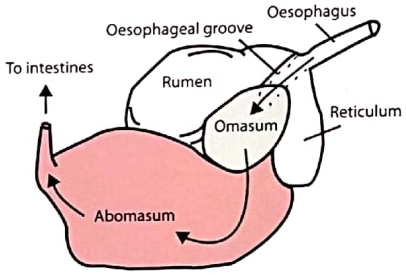
Physical	chewing and muscular action of the stomach(s) and intestines, which break down food particles and transport them through the system
Chemical	enzymes contained in various secretions come into contact with the food
Microbial	enzymes produced by micro-organisms, chiefly bacteria, which inhabit the tract

Digestion of food can take place in 3 regions:
- The stomach (abomasum and rumen)
- The small intestine
- The large intestine

Why is it important?
1. The neonatal calf is essentially a monogastric (simple-stomached) animal.
2. The abomasum is the only compartment actively involved in digestion at birth.
3. The digestive capability of the calf governs the type of diet that must be provided to ensure high growth rates and health.
4. The early digestive system is only able to digest high quality milk-based liquid feed.
5. This limitation is due to the presence or absence of digestive enzymes in the abomasum and small intestine.
6. Activity of most enzymes increases with age to digest fat, protein and carbohydrates.
7. Knowledge of digestion provides for management, nutrition and health of the growing calf .

Fact

The calf digestive system can develop and change so that it can digest fibrous feeds in 6-8 weeks



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Physiology

Digestion
Application

What are the stages of digestion development?

Stage	Age	Primary digestive organ	What diet is suitable?
Pre-ruminant	0-3 weeks	Abomasum	Liquid (colostrum, milk, milk replacer)
Developing ruminánt	4-8 weeks	Abomasum+ Rumen	Liquid + solid (starter)
Ruminant	8 weeks+	Rumen	Solid (starter, forage) + water

How is food digested?
Pre ruminant:
Oesophageal groove (a muscular fold of tissue in the reticulorumen) formation is controlled by neural-stimulation. Stimuli include the sights and sounds associated with feeding and a reflex response to swallowing. Milk, colostrum or milk replacer, received under these stimuli, bypass the rumen, passing directly into the abomasum. Oesphageal groove closure occurs whether drinking from a nipple/teat or pail/bucket. Head position can affect efficiency of closure.

Milk is digested primarily by acids and enzymes produced in the abomasum and small intestine. When whole milk, colostrum or milk replacer with a high proportion of skim, enters the abomasum, it forms a curd within 10 minutes. Curd formation is the result of coagulation of milk protein (casein) under the action of two enzymes, rennin and pepsin, and hydrochloric acid. Milk fat, water and minerals are also trapped in the curd that is retained in the abomasum for digestion. The curd is then digested slowly, over 12-18 hours, by stomach enzymes.

Other milk components such as water, whey proteins, lactose, immunoglobulins, minerals, etc. separate from the curd and pass into the small intestine for absorption and/or digestion. This occurs rapidly, as much as 200 ml per hour.

The newborn calf has limited carbohydrate digestion, except for lactose (milk sugar). Lactose is digested quickly, by the enzyme lactase, to glucose and galactose. They are absorbed quickly and provide immediate energy to the calf. There is little or no absorption or metabolism of volatile fatty acids (VFA) in neonatal calves. The rumen must develop this ability prior to weaning.

Milk replacer that does not contain skim milk powder, or only a very low level, will not form a curd/clot in the abomasum. Their digestion efficiency is controlled by the rate of passage of digesta.


Head position can affect efficiency of oesophageal groove closure

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Digestion
Application

How is food digested continued/...

Developing ruminant:
By 3-4 weeks of age, enzymes to digest starch and vegetable proteins are more active. Dry starter feed stimulates rumen development (see rumen development) and this produces rumen fermentation products. Microbial protein is highly digestible and contains a good amino acid profile.

A calf eating grain, takes approximately 3 weeks to establish a bacterial population that is able to ferment enough feed to contribute a major proportion of energy to the calf. Prior to this, additional energy is required from high digestible milk based products.

Ruminant:
In ruminants, the major part of all carbohydrates (including cellulose and hemi-cellulose) and proteins are digested by micro-organisms in the rumen. The ruminant animal is able to digest plant based products, including cellulose and hemicellose, by rumen fermentation to yield VFA's and microbial protein. The VFA's are absorbed through the rumen wall and contribute 66-75% of the energy derived from the feed. Carbohydrates (such as sugars and starch), microbial protein and undegraded protein that escape rumen digestion are digested in the abomasum and the end products absorbed through the small intestine wall.

What happens to the end products of digestion?

The end products of digestion are absorbed through the intestinal wall and rumen wall and utilised within tissues and organs of the calf for maintenance (sustain life) and production (growth). These chemical processes are called metabolism.

Energy is used to support body functions and enables protein to be used to build body tissues (growth). Energy is usually the first limiting factor for growth. The daily diet must provide enough energy with the right balance of protein to support a desired level of growth.

Milk or milk replacer are used more efficiently for maintenance and growth than dry starter feeds.

Calf efficiency of use of ME (NRC 2001):

Milk/milk replacer	86% for maintenance 69% for growth
Dry feeds	75% for maintenance 57% for growth

Fact
The composition of the diet must match the capability of the digestive system

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Physiology

Digestion
Evaluation

Summary of food components and their conversion to end products of digestion at different stages of development

Stage	Carbohydrate	Protein	Fat
Pre-ruminant	Lactose (milk sugar) → glucose	Casein → peptides, amino acids Whey protein → peptides, amino acids Vegetable proteins* → peptides, amino acids	Milk fat, fatty acids → fatty acids, glycerol
Developing ruminant	Lactose → glucose Starch → VFA's	Casein → amino acids Vegetable protein* → amino acids	Milk fat, dietary fat → fatty acids, glycerol
Ruminant	Starch → VFA's Cellulose → VFA's NSC (Non structural carbohydrates) → VFA's	Microbial protein → amino acids Dietary protein → microbial protein + UDP Microbial protein + UDP → amino acids	Dietary fat, fatty acids → fatty acids, glycerol

VFA = volatile fatty acids, propionate, butyrate and acetate

UDP = undegradable protein

* specialised vegetable proteins

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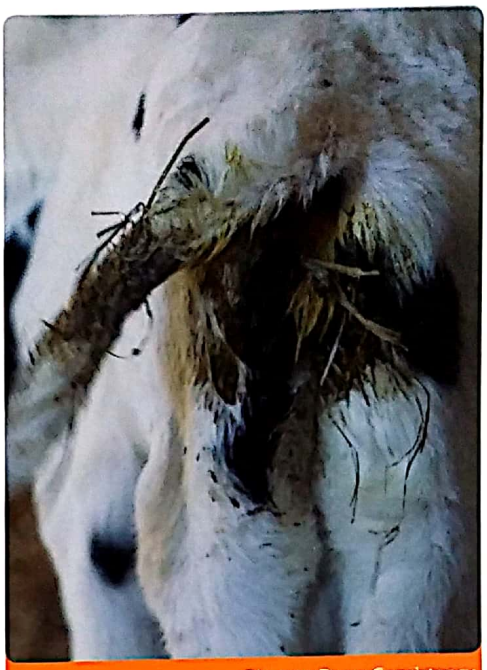
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Digestion
Evaluation

Observation signs that can indicate poor digestion
- Dung consistency
- Poor growth
- Increased susceptibility to disease

Common calf digestion disorders
There are three common digestion disorders:
(see signs of sickness for more information)

Nutritional Scours	Usually due to disruption of the digestive system; commonly caused by changes to the feeding program and/or stress.
Bloat	One or more of the microbes in the rumen grow too quickly under certain conditions and produce excessive gas. Susceptibility of animals to bloat is variable.
Acidosis	This occurs when there is a decrease in pH (acidity level) of the rumen or blood (ruminal or metabolic acidosis, respectively).



Observe Dung Consistency

Check list
- ✓ Digestion capacity of the calf changes from birth to weaning
- ✓ Newborn calf must only be fed high quality readily digestible milk products
- ✓ High quality feed, improves digestion efficiency for better growth and development
- ✓ Monitor digestion efficiency through faeces, growth and health

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Rumen Development
Explanation

Definition
The process of developing a fully functional rumen

What is it?
The four stomachs of a ruminant are the rumen, reticulum, omasum and abomasum.

Rumen - The first of the four stomachs of a ruminant. It stores and churns partially-chewed food that is then fermented by rumen bacteria (mainly) and protozoa. The rumen is an anaerobic (no oxygen) fermentation chamber for grains and forages, the end products are absorbed through the rumen lining.

Reticulum - Has a 'honeycomb' appearance, moves food into the rumen, enables regurgitation and acts as a collection area for foreign objects.

Omasum - Contains many laminae (tissue leaves) that help grind food. Water is squeezed out of the digesta (mixture of feed and fluid) and some nutrients are absorbed.

Abomasum - Also known as the true stomach this is where digestive enzymes break down food nutrients.

Rumination is a process of balls of food being regurgitated into the mouth for further chewing and mixing with saliva.

Why is it important?
The newborn calf is effectively born as a monogastric (single stomached) animal; the abomasum is the only functional stomach.

The young calf can only utilize high digestible feed such as milk and milk products during the first 3 weeks. Development of a healthy rumen is required for the transition from a pre-ruminant to a ruminant animal.

A healthy, functional rumen contains bacteria, protozoa and fungi to digest and break down complex carbohydrates and high fibrous feeds. Provision of suitable feeds enables rumen fermentation to supply a large amount of the energy needs.

Rumen bacteria also provide microbial protein (washed out of the rumen). Microbial protein is easily digested and absorbed in the small intestine and contains a good amino acid profile to meet the needs of the growing calf.

The rumen micro-organisms are able to synthesize nutrients such as B-vitamins and essential amino acids. Digestion of the micro-organisms makes these nutrients available to the animal.

Fact
A healthy, functional rumen is most important to enable the weaning transition

Fact
Correct rumen development at weaning improves economics

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Rumen Development
Application

Physiology

What are the stages of rumen development?
There are typically four stages of rumen development:

Week 0-3 Milk or milk replacer bypasses the reticulo-rumen (via the oesophageal groove) and is channelled directly to the abomasum for digestion

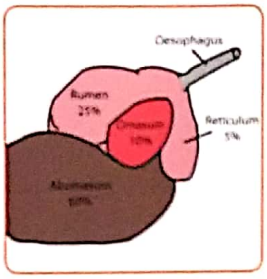
Week 4-8 Diet and dietary changes affect rumen development of the rumen epithelium, muscularization and volume

Week 8 + Post weaning - rumen fermentation by microbial population provides the calf with energy, protein and some vitamins

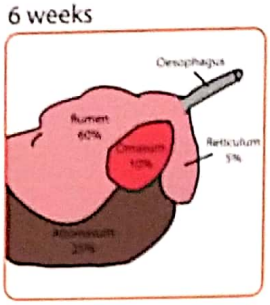
2-4 months The rumen has become fully functional

When do the stages of development occur?
As the calf grows and consumes different feeds, the four stomach compartments grow and change, as shown by the following diagrams.

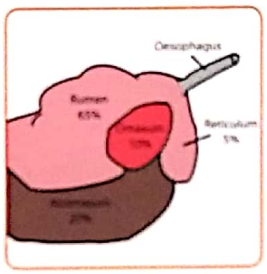
Birth



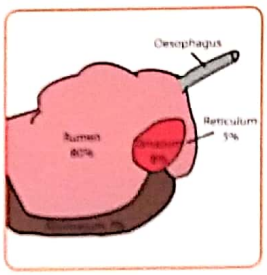
6 weeks



12 to 16 weeks



Mature ruminant



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Physiology

Rumen Development
Application

What does the rumen need for development?
Normal and early development of the rumen requires three main factors:

Bacteria As food enters the rumen, bacteria begin to grow. The types of bacteria that develop are dependent on the type of feed that the calf eats. Milk supports aerobic bacteria development, while dry starter feed supports anaerobic bacteria. Proper rumen development and function requires anaerobic bacteria.

Liquid in the rumen Bacteria in the rumen can only survive in a water environment. Milk/milk replacer does not constitute free water; it bypasses the rumen via the oesphageal groove that is active until 12 weeks of age. Clean, fresh water is required to enter the rumen. Water allows for absorption of VFA's, helps maintain rumen pH and stimulates dry feed intake.

Absorptive ability of rumen wall tissue The energy requirements of the new-born calf are met from absorption of glucose from the abomasum. There is little or no absorption or metabolism of volatile fatty acids (VFA) in neonatal calves. The rumen must develop this ability prior to weaning. The rumen consists of two layers, the epithelial layer and the muscular layer. The muscle layer is responsible for rumen contractions and gives support to the epithelial layer. The epithelial layer of the rumen wall is the absorptive layer. In the first few weeks, papillary growth, rumen muscularisation and rumen vascularisation are minimal to non-existent. The rumen wall is thin, slightly transparent with short and inactive papillae. 21 days after grain is fed rumen papillae develop and the bacterial population grow enough to ferment feed.

What is a healthy calf rumen?
- It has a dark coloration, caused by increased tissue mass and large blood vessels (vascularization)
- The papillae are numerous and visible without magnification
- The rumen maintains an anaerobic (absence of oxygen) environment for bacterial growth

What effect does diet type have?
- Diets composed of milk, concentrates, or forages have different effects on the rate and extent of rumen epithelial growth
- Dietary factors influencing papillary growth and development may not affect rumen muscularization or rumen volume and vica versa
- Grain (starch) intake rather than hay/straw intake is more important to ensure rapid rumen development and a smooth transition for early weaning

Goal

Provide suitable feeds to stimulate rumen papillae development for effective weaning with minimal growth check

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Rumen Development
Application

How does the rumen develop?

Physical changes	Why is it important?	How to encourage/stimulate good development?
Microbial population	To digest complex carbohydrates and high fibrous feeds	Bacterial growth requires correct temperature, anaerobic environment, feed to digest and water. Feed type governs the number and types of microorganisms established. Grain carbohydrates (starch) provide a rapid growth medium for rumen microorganisms that produce volatile fatty acids (VFA's) butyrate and propionate during rumen fermentation. Bedding, hair and the environment also provide micro-organism inoculation (not always favourable). Ideal rumen pH range for microbial growth is pH 5.5-6.5
Rumen papillae (Finger-like projections on the rumen epithelium)	They increase the surface area for absorption and utilization of microbial digestion end products, (VFA's). They should be numerous, dark colour (vascularised) and increase in length and width	VFA's produced from rumen fermentation, stimulate rumen epithelial development and provide nutrients for the calf. Butyrate is the most stimulatory, followed by propionate. Non-structural carbohydrates (starch) of calf starter produce the highest amount of butyrate and propionate.
Rumen muscularization	For rumen motility, processing and removal of food from the rumen	Dry starter feed encourages rumen motility. Stimulation is affected by particle size, extent of processing and level of effective fibre. Low particle size is least effective. Hay promotes growth of muscular layer after weaning.
Rumen volume/size	Prepare for feed capacity post weaning	Physical structure of feed can affect rumen capacity. Large amounts of roughage, preweaning can increase rumen size due to stretching of the tissues rather than papillae development. This is not desirable. Hay helps maintain a healthy rumen epithelium post weaning.

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Physiology

Rumen Development
Evaluation

Summary of the effect of diet type on rumen development

Pre-weaning diet	Rumen size	Papillae	Interior colour	Rumen wall
Milk only	Small	Short, limited	Light	Thin
Milk+ Starter feed	Medium	Long, wide	Dark	Thick
Milk + Hay	Large	Short, sparse	Pale	Thin
Milk + Starter + Hay	Medium/large	Some growth	Dark	Medium

Target

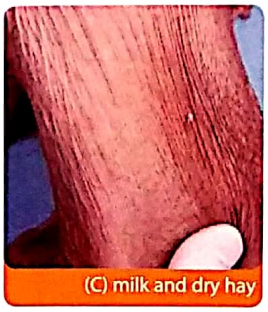
Top Tip

Grain (starch) intake is most important to ensure rapid rumen development and a smooth weaning transition

Comparison of calf rumen papillae development at 6 weeks


(A) fed milk only


(B) milk and starter feed


(C) milk and dry hay

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Rumen Development
Evaluation

The effect of diet type on rumen development and calf growth

Diet	Stage of rumen development	Effect on calf
Milk or milk replacer only	Rumen papillae, muscularisation and vascularisation are minimal to non-existent. The rumen wall is thin and slightly transparent.	Severe post-weaning growth check
Milk + starter	Dry starter feed does not stimulate the esophageal groove closure and so food enters the rumen. Microbial population (bacteria, protozoa and fungi) establishes naturally. Microbial end products of digestion are butyrate and propionate dominant and stimulate rumen development. Type of grain processing can influence rumen development.	Well-developed rumen Little growth check at weaning
Milk + forage (hay)	Larger particle size and increased fibre content of forage tends to result in a higher ruminal pH. Different microbial populations establish, with an acetate dominant VFA production which results in limited papillae growth and development and a thin rumen wall.	Calf appears pot-bellied Grain intake limited by bulky hay fibre filled stomach Likely post-weaning growth check
Milk + starter + hay	As milk + starter but stimulatory effect of starter feed will be reduced and dependant on animal feed preference.	Variable rumen development Possible growth check at weaning

Check list

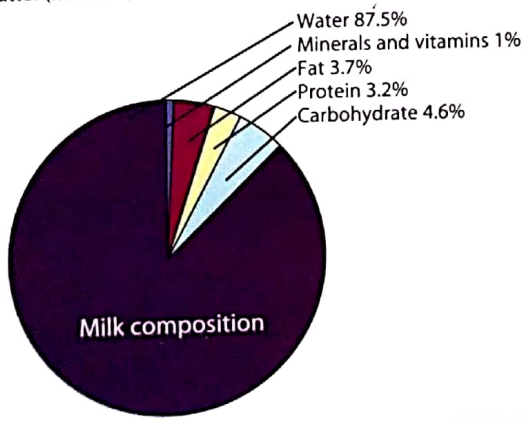
- ✓ Encourage intake of high quality calf starter feed from a few days of age
- ✓ Provide fresh clean water
- ✓ Limit forage (hay/straw) intake before weaning
- ✓ Ensure calf is eating 1kg starter feed per day for 3 consecutive days before weaning
- ✓ Minimize growth check post-weaning by effective rumen papillae development

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Nutrient Requirements
Explanation

Definition
The obligatory needs of an animal that are provided by substances in food that can be metabolized by the animal to provide energy and build tissue.

What does food contain?
Food is made up of 6 main nutrients: water, carbohydrate, protein, fat, minerals and vitamins. (See below for typical milk composition). When water is evaporated off, dry matter remains. This dry matter consists of organic and inorganic matter (minerals).



What are the components used for?
Water is essential for basic metabolic function; rumen bacteria and stimulation of dry feed intake. It carries nutrients throughout the body, dilutes and eliminates waste products, and is essential in regulating body temperature.

Dietary carbohydrate and fat are primarily used as energy sources. In the calf, energy is needed to maintain body function (maintenance, body temperature control) and for fat and protein growth.

Dietary proteins and microbial proteins from rumen digestion are primarily used as building blocks (amino acids) for protein synthesis, fundamental to maintenance, growth and reproduction.

Dietary essential minerals and vitamins are required in small quantities for normal metabolism, physiological function (maintenance, growth, reproduction) and health. They enable 'normal' skeletal and body development to occur. They enable chemical and enzymatic reactions, muscle function, nerve transmission, immune response etc. B-vitamins can be produced by micro-organisms but only, in sufficient quantity, by a fully functional rumen.

Goal
Provide correct quantity and balance of nutrients in a suitable volume to meet targets for growth and health

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Nutrient Requirements
Explanation

What form are they required by the calf?

Energy

Lactose (milk sugar) This should be the major carbohydrate source for young calves. The intestine of the calf possesses limited carbohydrate digestion, except for the enzyme, lactase.

Starch Digestion of starch and complex carbohydrates is dependant on the rate of rumen development and microbial growth. Usually digestion of starch starts within 2 weeks of age.

Fibre This is structural carbohydrates (cellulose, hemicellulose, lignin) that provide the physical form to plants. Vegetable proteins increase the level of fibre in the milk diet. Careful selection and formulation is required to keep the dietary fibre level to a minimum.

Fat Young calves require highly digestible fats, a correct fatty acid profile and saturation structure. Fats and oils must be adequately dispersed and a suitable droplet size for digestion in order to maximize growth potential. This is achieved by correct homogenisation and emulsification in processing. Saturated fats (e.g. milk fat, lard, coconut oil and palm oil) are most easily digested.

Protein

The quality of protein is based on its amino acid structure. It is important to consider:

- the amount of each amino acid required to meet needs
- the relationship of each amino acid to the others
- the availability of the amino acid to the calf
- the ratio of energy to protein to optimize utilisation

Calves utilize protein for growth more efficiently when the supply of amino acids more closely matches that of tissue requirements.

Milk protein is highly digestible and typically contains a more desirable amino acid profile than vegetable and cereal based proteins.

Non-milk proteins must be very carefully selected and formulated into the complete ration.

The amino acids, lysine and methionine can be added to improve the amino acid balance.

Water

It is provided via milk/milk replacer and as 'free' water. Water must be fresh, hygienic and readily available to the calf.

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Physiology

Nutrient Requirements
Explanation

Minerals and vitamins

Minerals and vitamins are present in feeds in varying amounts. Vitamins deteriorate with time and exposure to light, moisture, air, pH, trace minerals. Source, form and stability are important to maintain viability and absorption by the calf. Different sources show different solubility, suspendability, distribution in the premix and absorption characteristics. Water dispersible forms must be used for milk replacers.

The foetal calf is born with low status of some vitamins, e.g. Vitamins A, D, E. Vitamin A and E help support the young calf's immune response. Adequate levels of vitamins A, D, E, K, B-group must be provided daily from food sources. B-group vitamins & vitamin K are added to young calf diets to support the calf until the rumen is fully developed and they can be supplied adequately from microbial production.

Why is it important?

- To sustain life of the calf (body maintenance)
- To provide nutrients for required growth and development
- To support a strong immune system



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Nutrient Requirements
Application

What does the calf need?

The amount of energy and protein required is divided into a maintenance requirement and a growth requirement. Food digestion end products are first used for maintenance, then available for growth and finally immune function. If maintenance energy requirement is not met by feed, then the calf will be partially dependent upon the mobilization of body energy reserves. This will reflect in low or negative growth rates.

Maintenance Maintenance is the amount of energy and protein to support normal body function, including body temperature. Requirements are dependant on body weight and environmental conditions (temperature, humidity, windspeed, hair coat etc). Cold weather and other environmental stress increases the maintainence energy requirement.

Growth This is the nutrients required to build tissues. Energy is most often the limiting factor to growth. The diet must provide the correct balance of energy and protein to support the growth level required. Protein requirements increase as rate of gain increases. High levels of protein require increased dry matter intake; this ensures that sufficient energy is provided to utilize the higher level of protein.

Dry matter intake This influences rate of gain. Intake must be adjusted for rate of gain and as the calf grows.

Immune function Provides essential protection against pathogen exposure. Low level nutrition impairs immune response.

How to provide nutrients to the calf?

Nutrients for calves are provided by liquid feeds, starter grain and water. At birth, the calf has limited energy reserves that will last <1 day.

Day 1-2 1st feed – Colostrum

Day 2 onwards Liquid feeding program to meet weaning targets

Post weaning High quality starter feed and forage

Feed must have a high digestibility, low bacterial contamination, complete nutrient balance and be fed at a level to meet the development and production requirements of the young calf. Feed must be consistent to avoid digestive upsets and poor growth.

Fact

Early gains are most economical

Efficiency of energy gain is greatest in the first 2 weeks of life



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Physiology

Nutrient Requirements
Application

Calf nutrient requirements

The following tables provide a summary example of the nutrient requirements as published by NRC, Dairy 2001. Detailed tables are not possible in this publication but are available from nutritionists and specific publications.

Calves are usually divided into 4 categories

1. Replacement calves fed milk or milk replacer
2. Replacement calves fed milk/ milk replacer and starter feed
3. Veal calves
4. Ruminant calves (from weaning to 100kg BW)

The nutrient content and concentration of liquid feed and daily feed intake provide the nutrients available for maintenance, growth and immune function.

The daily gain will also depend on the environmental temperature which effects the energy needed to maintain body core temperature.

Daily dry matter intake (DMI)= milk concentration x litres fed/day

DMI x ME of milk solution = maintenance + expected daily gain

Minimum mineral and vitamin requirements recommended for young calf diets

	Units (DM)	Whole milk	Milk replacer	Calf starter
Calcium	%	0.95	1	0.7
Phosphorus	%	0.76	0.7	0.45
Magnesium	%	0.1	0.07	0.1
Sodium	%	0.38	0.4	0.15
Potassium	%	1.12	0.65	0.65
Chlorine	%	0.92	0.25	0.2
Sulphur	%	0.32	0.29	0.2
Iron	mg/kg	3.0	100	50
Manganese	mg/kg	0.2-0.4	40	40
Zinc	mg/kg	15-38	40	40
Copper	mg/kg	0.1-1.1	10	10
Iodine	mg/kg	0.1-0.2	0.5	0.25
Cobalt	mg/kg	0.004-0.008	0.11	0.1
Selenium	mg/kg	0.02-0.15	0.3	0.3
Vitamin A	IU/kg	11,500	9000	4000
Vitamin D	IU/kg	307	600	600
Vitamin E	mg/kg	8	50*	25*

* research suggests higher amount is recommended for optimum immune function.

B-vitamins recommended for pre-ruminant and pre starter rations

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Nutrient Requirements
Application

Daily energy and protein requirements of dairy calves fed milk or milk replacer and starter

LW (kg)	Gain (g/d)	DMI (kg)	ME (MJ/d)	CP (g/d)
30	400	0.56	9.75	141
35	400	0.61	10.67	145
40	400	0.66	11.55	148
40	600	0.83	14.39	205
45	400	0.71	12.38	151
45	600	0.88	15.36	209
50	400	0.76	13.18	154
50	600	0.94	16.28	212
50	800	1.13	19.62	270
55	400	0.8	13.93	157
55	600	0.99	17.15	215
55	800	1.18	20.50	273
60	400	0.84	14.68	159
60	600	1.04	18.03	217
60	800	1.24	21.59	275

LW = liveweight, DMI = dry matter intake,

ME = metabolisable energy, CP = crude protein

Daily energy and protein requirements of weaned (ruminant) calves

LW (kg)	Gain (g/d)	DMI (kg)	ME (MJ/d)	CP (g/d)
50	500	1.27	16.44	238
50	600	1.86	18.24	276
60	500	1.41	18.24	246
60	600	1.56	20.21	284
60	700	1.71	22.22	322
60	800	1.87	24.26	359
70	500	1.54	19.95	254
70	600	1.7	22.00	292
70	700	1.86	24.14	330
70	800	2.03	26.32	367
80	500	1.66	21.59	262
80	600	1.83	23.77	300
80	800	2.18	28.24	375
90	600	2.09	25.40	309
90	800	2.48	30.08	385
100	600	2.22	26.99	316
100	800	2.63	31.88	392



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Physiology

Nutrient Requirements
Evaluation

How are nutrients expressed?

Nutrients are usually expressed as:

- amount per unit of diet (e.g. % or g/kg)
- amount per unit bodyweight (e.g. g/kg BW)
- daily amount required per head (e.g. g/h/d)

It is always important to compare the same units of measure. Nutrients are most easily expressed on a dry matter basis.

To convert 'as fed' (AF) to dry matter (DM) divide the nutrient level (AF) by the dry matter.

E.g. 10 kg AF @ 88% DM = 10 ÷ 0.88 kg DM
= 11.36 kg DM

Energy is usually expressed using the metabolizable energy (ME) system. NE is difficult to measure.



Typical nutrient units of measure

Nutrient	Metric	Imperial
Energy	Joules (J), megajoules(MJ)	Calories (cal)
Protein	Percent (%), grams (g)	lbs
Minerals	major - %, g minor - %, mg	
Vitamins	IU, g, mg, µg	

How to assess feed nutrient requirements?

A) Determine calf bodyweight - ideally use scales
Determine growth targets

B) Assess nutrient composition of liquid and dry feeds (look at labels/analysis)
Assess stage of development

C) Monitor feed consumption by the calf
Monitor environmental conditions and adjust diet accordingly

Unit Equivalents

1 calorie	= 4.184 Joules
1 litre	=1.06 quart
1 litre	= 2.11 pints (US)
1 litre	= 1.76 pints (imp)
1 litre	= 33.81 fl oz
1g	= 0.035oz
1kg	= 35.27oz
1 kg	= 2.2lbs
1 gall (US)	= 3.785 litres
1gal (imp)	= 4.54 litres
1KJ	= 1000 Joules
1MJ	= 1000 KJ

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Nutrient Requirements
Evaluation

Troubleshooting/ What can go wrong?

Cause	Effect
Insufficient nutrients (low feeding level or inappropriate ration)	Limited growth Health disorders Reduced immune response
Excess nutrients (too high feeding level or inappropriate ration)	Digestive upsets Nutrient wastage
Excess or an imbalanced protein to energy intake	Increased energy and nitrogen loss Inefficient and excess must be excreted
Stress (management, nutritional, environment)	Can affect apparent digestiblity of energy, utilization of feed, immune response
Cold climatic environment	Increases the need for energy to maintain growth rate and optimal immune response
Hot climatic environments	Reduces appetite and so nutrient intake Negative effect on performance and health

Check list

- ✓ Match feed to the development of the digestive system
- ✓ Nutrient levels must meet maintenance and growth needs
- ✓ Provision of correct nutrients can enhance immune function
- ✓ Adjust feed nutrient requirements for environmental challenges
- ✓ Efficient growth improves profitability

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Section 2

Calf Rearing Guide — Practical and easy to use

Feed

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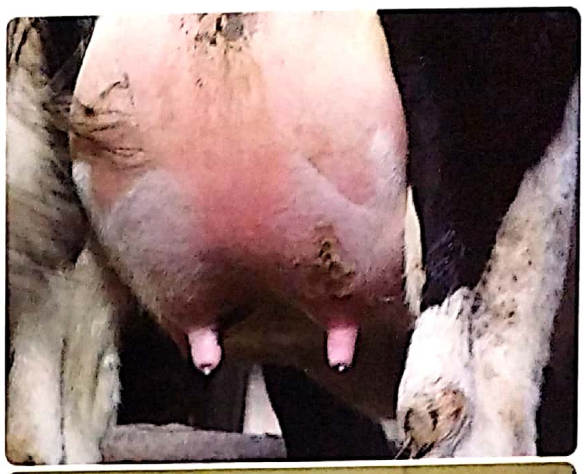
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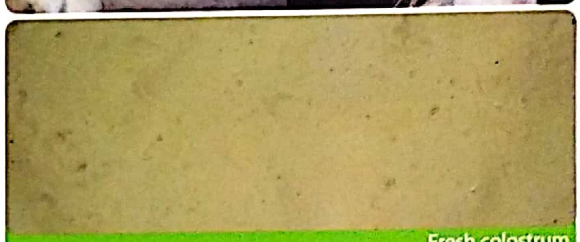
Colostrum
Explanation

Definition
First 'milk' secreted by the mammary gland for the first 24 hours after birth.

What is it?
A thick, creamy, yellow fluid that contains:

Component	Role
Immunoglobulins: IgG (80-90%) IgA (5-10%) IgM (7-10%)	Large protein molecules which help animal fight infection Helps protect gut from bacterial invasion Absorbed Ig's for early passive immunity Identify and destroy absorbed pathogens Help in prevention of septicemia
Protein	Protein synthesis Ig absorption
Energy (Fat and Lactose)	Newborn has low energy stores, poor insulation Need for thermoregulation Help prevent hypothermia
Vitamins and minerals	Vitamins A, D and E do not cross the placenta in significant amounts Important to the animal in resistance of disease
Gut growth factors	Promote gut growth and development, especially during the first 24-48 hours after birth





Fresh colostrum

Feed

Colostrum
Explanation

Fact

The immune system is not developed in the new born calf and this is the only way it can fight infection

Top tip!

Calves with adequate colostrum antibodies are more likely to fight health threats

Why is it important
Newborn animals do not have a fully developed immune system.

The intestine is not fully developed for several months; colostrum Igs help protect the gut from pathogens.

Newborns are vulnerable to infection and disease from the environment.

- Newborn calves do not acquire passive immunity in utero
- Immunoglobulins do not pass across the placenta prior to birth

Colostrum must provide Ig's for passive (natural) immunity transfer for the first month and partially up to 6 months of age, while the immune system matures.

Colostrum provides a high concentration of energy, protein, vitamins and other nutrients.

Colostrum has a laxative effect and growth factors stimulate the normal function and development of the digestive tract.

Effectiveness of natural immunity depends on the quality, volume, timing and cleanliness of colostrum received.



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Colostrum
Application

What to feed?

Ideally use colostrum from the mother

Or use pooled colostrum from same herd
Or pooled colostrum from another herd
Or good quality colostrum supplement

All dependant on availability, Ig content, bacterial, pathogen contamination, transmissible diseases etc.

When to feed?

Gut closure (ability to absorb Igs stops) is complete in the calf by about 24 hr after birth

- **Feed colostrum as soon as possible** (within first hour, preferably within 15mins of birth)
- Feed total quantity within 6-8 hours following birth to ensure highest absorption of IgG

Fresh colostrum must be fed within one hour after collection
Stored colostrum must be fed within 30 minutes of being brought to room temperature.

How much to feed?

Typically total volume required is 10% of birth weight.
Minimum/Ideal volumes:
Large breeds (Holstein/Brown Swiss, Red & Whites) **6litres**
Small breeds (Jersey, Guernsey, Ayrshire, Herford X) **4 litres**

Recommended levels are dependant on IgG level of colostrum fed.
Minimum 200g IgG per calf within 6-8 hours of birth.

How to feed?

- Feed with a nipple bottle (2-3l) or nipple pail
- Feed at body temperature (39°C)
- Feed half total quantity within 15 minutes if birth
- Feed remainder within 6-8 hours of birth

Use a stomach tube only if necessary. (Take care that the stomach tube is not forced into the windpipe- consult your veterinarian for advice).

Top tip!

Know your colostrum quality

Healthiest calves are fed colostrum as soon as possible and as much as possible



Calf fed colostrum

Feed

Colostrum
Application

After Ig level test

Targets

< 25% incidence of sickness

<5% mortality



Freezer bags - ideal for storage

How to collect?

Collect colostrum from the first colostral milking, as soon as possible, following delivery of calf

Do not allow calf to nurse prior to collection

Only collect colostrum from healthy cows and sanitize the udder

Collect, store and feed colostrum in clean, sanitized vessels (ideally 1-2 litre, maximum 4litres)

Never let colostrum sit at room temperature

Colostrum is a perfect medium for microbial growth

Always maintain the quality and biological safety

How to store?

Cool as soon as possible
Pre-chill quickly to 15°C (60°F) within 30 minutes of milking (E.g. float clean ice bottles in colostrum with1:4 ice to colostrum ratio)
Cool to 4°C (40°F) within next 2 hours
Store in a refrigerator 1-2°C (33-35°F) for up to 7 days
Consider using a inhibitor of bacterial growth (e.g. potassium sorbate) for storage > 3 days

How to store - cont'd

Tested colostrum can be frozen in feed quantities, for up to one year

Freeze in 1 litre zip-lock freezer bags or ice cube trays for easy defrosting

Frost free freezers are not optimal for long term storage as they undergo freeze/thaw cycles

Check freezer temperature is -20°C (-5°F)

Carefully label all containers with identification, Ig level and date

How to thaw?

Thaw colostrum slowly using a warm water bath

Microwave thawing must use low power and for short periods

Overheating can destroy the antibody effectiveness

Pour off liquid to minimize heating

Refrigerate thawed colostrum as soon as possible to reduce bacterial growth

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Colostrum
Evaluation

Feed

What factors cause differences in IgG concentration?

Factor	Reason
Breed	Jersey cows have the highest Ig levels (G,A,M) and Holstein the lowest IgG; Guernsey, lowest IgM,IgA
Immune status of dam	Depends on disease history, exposure and dry cow vaccination program (at least 3 weeks prior to calving)
Age	Relates to pathogen exposure. IgG and IgA lower from first-calf heifers than 3+ parity cows
Environmental temperature	Extremes in temperature can lower Ig levels
Timing of 1st milking	IgG levels decline rapidly post calving, milk as soon as possible after calving
Length of dry period	Ig content is reduced by a short dry period (<45days)
Dry cow nutrition	Inadequate protein, energy, vitamins etc. lowers quality
Mastitis	Bacterial contamination
Running or precalving milking	Reduces Ig levels
Processing and Storage	Overheating can destroy the antibody effectiveness

The 3Q Rule

Every calf to receive the correct colostrum

Quality
Quantity
Quickly

Quality

IgG >50 g/l

Low bacterial counts

Quantity

4-6 litres

Quickly

Within 6-8 hours following birth

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Feed

Colostrum
Evaluation

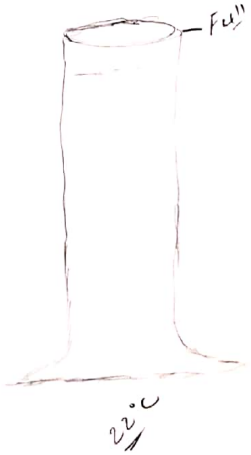
How to evaluate colostrum quality?

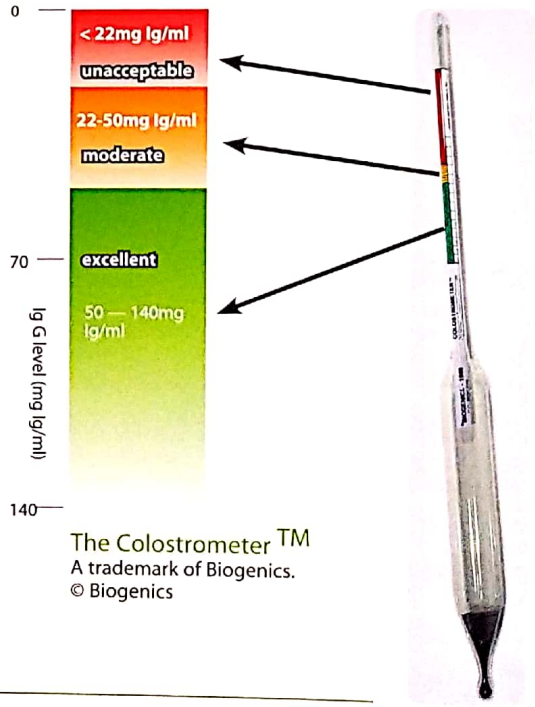
A) Assess colostrum IgG concentration

An on farm colostrometer can quickly and easily indicate the IgG level. It is a hydrometer and measures specific gravity which is correlated with antibody concentration.
A colour coded scale is used to identify the quality range

1) Place colostrometer in a full cylinder of colostrum, let it overflow and allow it to float
2) Read the colour coded scale located inside the unsubmerged portion of the instrument
3) Clean colostrometer thoroughly for next test

Colostrum must be tested at room temperature (22°C, 72°F) as results are temperature related. High temperatures under-estimate IgG and low temperatures over estimate IgG. If at extreme temperatures (e.g. body temperature or refridgerator, results can be adjusted using the following temperature correction.





The Colostrometer ™
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Temperature correction:

Corrected IgG (mg/ml) = (IgG-13.2) + (0.8xTemp°C)

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Colostrum
Evaluation

Feed

B) Assess biological quality
Colostrum can easily be contaminated with bacteria during collection and storage. Bacteria multiply very quickly, e.g. E.coli double in number every 20 minutes at body temperature.

Cleanliness and prompt feeding or chilling for storage will reduce the risk of bacterial growth.

Biological quality can be measured by:

Standard plate count (SPC)

Total bacterial count (TBC) and

Faecal coliform counts(FCC)

Test samples at several points, e.g. collection, feeding, storage.

Do not use bloody colostrum or colostrum from mastitic cows.

Test herd or bulk tank for transmissible diseases. i.e. Johne's disease, BLV, Salmonella, Mycoplasma, Leptospira.

C) Assess adequacy of passive immunity transfer
This can be evaluated by blood test using a refractometer or blood kit. Total serum protein is highly correlated to IgG levels. The test and interpretation requires care.

Test from 12 hours to 24 hours after birth
(a minimum 6 hour interval is required from feeding colostrum and testing blood serum)
Calves must be less than 5 days of age.

The test evaluates the effectiveness of the volume of colostrum and timing of its feeding to provide a minimum level of immune protection.

Blood levels less than targets indicate a failure of passive transfer (FPT).

FPT reduces the calf ability to fight pathogens and increases risk of illness and organisms shed into the environment

Targets

Biological
TBC <100,000 cfu/ml
FCC < 10,000 cfu/ml
SPC < 5,000 cfu/ml

Blood
Serum total protein >5.5g/dl

Plasma IgG >10g/l

Note
Equivalents
10g/l = 1000mg/dl
1000mg/dl = 10 mg/ml
10 mg/ml = 10g/l

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Feed

Colostrum
Evaluation

Colostrum alternatives
If quality colostrum supplies are limited there are a number of colostrum replacers/ supplements available and derived from several sources.

Colostrum replacers must provide > 100 mg IgG per complete feeding and nutrients (fat, protein, vitamins, minerals) required by the newborn calf.

Colostrum supplements usually provide lower levels of Ig and no additional nutrition. They must be fed alongside colostrum.

Products are usually a dry powder to mix with water, beware not to dilute colostrum.

All powder products must be mixed thoroughly and hygienically to manufacturers recommendations.

Fact
Calf survival is 3% greater when blood IgG > 10g/l

Ig ingredient sources

Bovine Serum	Contains significant amounts of Ig's Approximately 50:50 IgG_1 and IgG_2, with little IgM or IgA. AEA can be similar to colostrum
Spray dried colostrum from vaccinated cows	Contains a blend of colostrum to a specific IgG level
Cheese whey	Ig's from whey obtained by special processing Usually IgG level 25-30g/dose
Egg antibodies	Spray dried, hyper-immunised egg products contain Ig to specific bacteria and viruses commonly responsible for nursery scours. Their primary role is to protect the absorptive surface of the intestine from pathogen attack and to make pathogens inactive.

Check list
- ✓ Quality assessed (IgG and bacterial)
- ✓ Quantity sufficient to feed all calves
- ✓ Quickly fed within 6-8 hours birth (1st feed within 1hr birth)
- ✓ Colostrum stores /alternatives available
- ✓ All equipment sanitized
- ✓ Test for success of adequate passive immunity transfer

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Liquid Feed
Explanation

Definition
A substance that is able to flow and meet nutrient and physical requirements of the young calf.

What are they?
There are 5 liquid feeds available for pre-weaned calves

Colostrum	1st 'milk' secreted by the mammary gland for the first 24 hours after birth. Low lg quality colostrum can be fed later as a feed source
Transition Milk	Milk from up to the first six milkings
Whole Milk	Saleable milk from the bulk tank
Milk Replacer	A blended powder based on dried products from the milk processing industry, fats and oils, minerals, vitamins and other additives
Waste & Discard Milk	Milk that cannot be sold as from cows with mastitis or other bacterial disease that have had antibiotic treatment. It is advised that antibiotic waste milk should not be fed to calves

What do they provide the calf?
The nutrient value of a liquid feed is best compared on a dry matter (solids) basis. The table provides a typical nutrient comparison of the feeds. This analysis can be compared with the nutrient balance required by the calf for maintenance and growth to calculate the amount of that feed required to meet targets. See nutrient requirements for tables and seek advise from a nutritionist.

Why is it important?
A newborn calf requires liquid feed of high nutritional balance and hygiene. Colostrum is important at birth, to provide vital immunoglobulins, energy and growth factors
Goals for calf growth, health and weaning age influence the type of feed required. The largest costs in heifer rearing are feed and the number of day's growth to achieve first calving.



Nutrient	Colostrum	Transition milk (3rd milking)	Whole milk	Milk replacer conventional	Milk replacer enhanced
Dry matter %	24	14.1	12.4	12.5	15.0
Fat % DM	28	27.6	28.8-32	15-20	15-18
Protein % DM	58	36	26	18-23	26
Lactose % DM	11	31.2	39	48	40
Ash% DM	4	5.2	5.6	8	8
Energy(DE) Mcal/kg DM	4.83		5.6	4.1-4.6	4.6-4.7
Energy (DE) MJ/kg DM	20.1		23.4	17.1-19.2	19-19.5

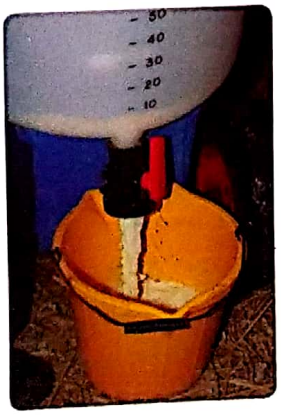
Addition of Lactose in Colostrum

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Feed

Liquid Feed
Explanation

Attention
Extreme care is required when handling liquid feeds



How to collect?
Maintenance and sanitation of collection, storage and feeding equipment are essential for maintaining quality and biological safety of liquid feed (see hygiene).

Only collect colostrum, transition milk and whole milk from healthy cows and sanitize the udder.
Never let liquid milk sit at room temperature. It is a perfect medium for microbial growth. Bacterial numbers double every 20 minutes at body temperature.
High bacterial count feed is a too a high load for the young calf gut to handle.

How to store?
- Excess colostrum, transition milk, whole milk can be stored in a refrigerator (0-4°C, 32-39°F) for up to 7 days
- Clean, liquid milk can be frozen for up to 6 months
- Freeze in single feed quantities, in a suitable container, for easy defrosting
- Check freezer temperature is -20°C (-5°F)
- Frost free freezers are not optimal for long term storage as they undergo freeze/thaw cycles
- Carefully label containers with indentification and date

How to store - cont'd
- Milk replacer: store in cool, dry sealed container. Check shelf life on bag, usually 12 months from date of manufacture

How to thaw?
Thaw liquid milk slowly using a warm water bath.

Microwave thawing must use low power and for short periods. Pour off liquid to minimize heating.

Overheating can denature protein and so reduce its quality to the calf.

Refrigerate thawed milk as soon as possible.

Milk will need warming for successful feeding; agitation is suggested to ensure even heating.

How much to feed?
See management section and feeding programs

It is important to have a stable supply of milk so that young calves' diet is consistent.

Any changes in feed must be gradual to avoid digestive upset.

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Liquid Feed
Application

What is pasteurisation?
Pasteurisation is a process of heating milk to a specific temperature for a specified amount of time to reduce undesirable bacteria to negligible levels. Reduction in pathogen load depends on the effectiveness of the system and initial pathogen loading. Heating destroys or reduces the presence of viable bacteria. Some bacteria will survive the process. These are either heat-tolerant bacteria or a result of a very high concentration of bacteria in raw milk.
The process is a function of time and temperature.

Pasteurisation processes
Batch process- Low temperature long time (LTLT) 63-65°C (145°F) for 30 mins

LTLT process heats milk to the target temperature and holds it for 30 minutes, then rapidly cools the milk to feeding or storage temperature. The unit should have an agitator to allow for even heating.

Continous flow- High temperature short time (HTST) 72°C (161°F) for 15 secs.

HTST pasteurisers circulate the milk through a network of heated coils, rapidly heats milk to target temperature and holding it for 15 seconds before cooling. Care and attention must be taken to avoid denaturing of proteins and vitamin loss etc.

On farm pasterisation
On farm pasteurisation offers a method of reducing pathogen load of waste milk but does not completely remove pathogens or eliminate the risk of disease transmission. The efficacy of pasteurization in destroying Mptb (the agent causing Johne's disease) remains controversial between the different pasteurization systems. It is not effective when samples are heavily contaminated.
Pre and post pasteurized milk must be chilled to prevent bacterial growth and fermentation. A stable supply is required to be effective.

Consideration for on-farm pasteurisation units

Numbers of calves to be fed daily	Units vary in volume per batch (LTLT) or rate of daily pasteurization (HTST)
Installation requirements	Hot water, water supply, electrics, space, drainage etc.
Daily requirements	Sanitation, training, labour time, heat up time
Variable costs	Service, movement and storage of milk, pathogen tests, (e.g.Johnes, mycoplasma), hygiene monitoring
Economics	Should be carefully considered (large calf numbers suggested for early pay back)

Top tip!
Successful pasteurisation requires a relatively clean product and strict mangaement controls

Pasteurizing Colostrum
Pasteurizing colostrum presents challenges due to congealing and significant loss of antibodies/ immunoglobulins.
Small volumes by the batch pasteurization method have had the best success. It requires high management and monitoring.It is generally not recommended to pasteurize colostrum.

Liquid Feed
Evaluation

Liquid feed comparison
Each liquid feed has advantages and disadvantages.
Evaluation of the suitability for use can include the six factors below which are detailed on the next page.

Nutrient Balance	What does the feed provide? Inadequate energy intake, inappropriate concentration, volume, nutrient content, mixing, temperature etc. can compromise growth & immune function.
Availability	Is sufficient feed available for the number of calves and the feeding program? Consistent feed supply is required to reduce digestive upsets.
Consistency	Can a consistent analysis and quality be provided to maintain growth targets?
Storage & Handling	How convenient is it to store, preserve if necessary and accessibility of this stored feed to the calf unit?
Disease Risk	What is the bacterial quality? How high is the potential for exposure to disease causing organisms? It is easier and more cost effective to try and prevent disease situations than to cure them once they have become established.
Economics	What is the cost of the feed per unit weight gain? What space is required, time and handling requirements for different feeding systems? What is the cost of storage/preservation? What is the cost of treatment or loss and risk of transmission of infectious diseases to calves? What are installation costs, electricity, labour, depreciation, interest payments etc.

It is important to consider and compare all the factors as well as suitability for the number of calves produced, the feeding system(s) available and the goals of the calf rearing program.

Goal
Provide a high quality feed, suitable for the rearing system, to meet the growth, health and economic targets

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Liquid Feed
Evaluation

Liquid feed comparison

Liquid feed	Nutrient balance	Availability	Consistency	Storage/handling	Disease risk	Economics
Waste colostrum/ Transition milk	Variable, dependant on milking number/ no. cows etc. Dilution suggested to reduce solids content and scour risk	May be insufficient	Variable Warm/hot weather can result in putrefactive fermentation.	Can be high, Requires storage, preservation, e.g. refrigeration, freezing, fermentation	Moderate Know bacterial count; can be pasteurised but can clog machine	Low - Moderate depends on storage, preservation costs
Whole milk	Good balance but is low in some vitamins and minerals (important for maintaining healthy tissues, immune response and growth etc)	Moderate	Depends on herd profile, e.g. stage of lactation of herd	Convenient if bulk tank near to calf housing	Moderate know bacterial count. Can be pasteurised	High Depends on saleable milk price and pasteurisation costs etc)
Waste milk	Good but concerns on development of antibiotic resistance for intestinal bacteria in calves. Antibiotic residues may result in unsaleable calves after the withdrawal period	May be insufficient	Must assess quality, know disease status of cows	Needs high maintenance	High Depends on disease status of cows. Not suitable for calves group fed or <4 days. Can be pasteurized	Low but high risk
Milk replacer	Wide range available Can be formulated and mixed to meet requirements according to growth targets	High	High from quality products and if well managed	Very convenient	Very low	Range available depends on ingredients, specification and processing

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Feed

Liquid Feed
Evaluation

Calculation of comparative feed costs

Always: Compare feeds on a 'dry matter' basis
Be consistent with units

Examples:
a) Milk Replacer (Typical 'dry matter' is 95%)
Cost of 1 kg of 'dry matter' = (cost per bag ÷ weight per bag) ÷ 0.95

b) Whole Milk (Typical 'dry matter' is 12.5%)
Cost of 1 kg of 'dry matter' = market price per litre of milk ÷ 0.125



Do not feed calves

Milk containing antibiotic residues

Milk with high bacterial counts

Unpasteurized waste milk

Milk from cows with transmissible pathogens i.e. Johnes disease, BLV, Salmonella, Mycoplasma, Leptospira

Assess - Test - Feed - Monitor



Check list

- ✓ High nutrient digestibility and bacterial quality feed
- ✓ Consistent supply of liquid feed for the number of calves
- ✓ Present to calf correctly
- ✓ Sanitize all equipment
- ✓ Store liquid feed to maintain low bacterial count
- ✓ Know what you are feeding

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Milk Replacer
Explanation



Definition
A blended powder formulation based on dried products from the milk processing industry, fats and oils, minerals, vitamins and additives

Alternative name – milk formula

What is it?
A milk replacer is a complete, balanced, nutritional feed for young animals from birth to weaning.
It provides an alternative liquid feed source to maternal milk, when it is not available, uneconomic, contaminated or not suitable for the feeding system.
Technical knowledge of raw materials, animal physiology and experience result in specialized milk replacers for any young animal.

Milk replacer can be formulated from four groups of ingredients.
The main ingredients used are by-products of the milk processing industry. They come either from separation of butter fat (skim based) or from cheese production (whey based). The skim and whey based products are digested differently by the calf, skim based products forming a clot in the abomasum. (see digestion)

Why is it important?
Milk replacer can provide a consistent, quality feed to meet growth and development targets of the young calf
The product is convenient, easily stored and readily available
Milk replacer is manufactured to high hygiene standards and offers a biosecure alternative liquid feed when diseases such as Johne's, BVD, salmonella, E.coli, mycoplasma are present on farm.

Milk replacer can provide an economic liquid feed for calf rearing.

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Milk Replacer
Explanation
Feed

Milk replacer ingredient groups

Group	Sub-group	Example Ingredients
Milk Products	Skim based	Dried skimmed milk, dried butter milk, caesin, fat-filled skim milk powder
	Whey based	Dried whey protein concentrate, dried whey, dried whey product (delactosed whey)
Non-Milk Products	Soya based	Soya protein concentrate (protein portion without soluble carbohydrates, contains some fibre); Soya protein isolate (protein with carbohydrate removed, including fibre); Soy flour* (basic form not ideal for calves but can be processed to improve digestibility/reduce allergic reactions)
	Animal based	Animal plasma (Not permitted in some countries) Egg protein* (spray dried whole egg or whole egg and albumin)
	Others	Hydrolysed wheat protein (treated to improve protein solubility) Modified Potato protein* (by-product of starch extraction, quality can vary) Starch (added as a legal requirement in the manufacture process of skim products)
Fats	Animal fats	Edible Lard, tallow, choice white grease (provide medium and long chain fatty acids, 88-96% digestible)
	Oils	Coconut, palm, fish oil (provide short & medium-chain fatty acids, 92-96% digestible)
	Emulsifers	Lecithin (improves mixability and digestibility)
		* may vary in quality, must be carefully sourced and formulated

.....continued on next page

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Milk Replacer
Explanation

Milk replacer ingredient groups

Group	Sub-group	Example Ingredients
Additives	Vits and Mins	Specialised vitamin/mineral premix is essential for normal body functions to support growth and health.
	Probiotics#	Also called Direct-fed microbials(DFM) are live cultures of naturally occurring microorganisms that stabilise the gut environment and may enhance intestinal development, eg. selective yeast cultures and lactic acid producing bacteria.
	Prebiotics#	Structural carbohydrates that are not digested by the animal and alter microbial populations to favour beneficial bacteria in the gut. Mannanoligosaccharides (MOS) contain fragments which selectively bind with pathogens preventing their attachement to the gut wall. Fructooligosaccharides (FOS) provide nutrients for benefical bacteria to flourish.
	Functional proteins#	Bind with and inactivate common 'on farm' pathogens and/or toxins in the gut and so prevent bacteria and virus adhesion to the gut wall. They do not displace bacteria already bound to epithelial receptors. Examples include: - Polyclonals antibodies (from hyperimmunised egg proteins) bind selective pathogens. - Lactoferrin binds iron which limits E.coli and rotavirus growth. - Allicin inhibits growth of bacteria by binding to an enzyme.
	Medicinal Additives	Coccidiostats (decoquinate, lasalocid) and antibiotics (chlortetracycline, oxytetracycline, neomycin). Can be used for improved growth & feed efficiency or prevention of certain diseases. Permission for use, inclusion rates and withdrawal must meet legal requirements of country.
	Acidifiers	Low levels reduce gut pH that limits pathogen growth. It can also aid in the digestion of milk proteins, aids milk clotting. It can increase time that milk remains fresh after mixing. E.g. 2-3 days depending on weather conditions. Level important so as not to affect palatability and feed intake.

 # Mode of action and research variable; consult suppliers/manufacturers for more information.

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Milk Replacer
Application



Target

Milk replacer suitable for:

- Feeding system
- Growth goals
- Economic goals
- Management
- Health status

How to choose a milk replacer?

There are many different products and types of milk replacer available for calf rearing. The important parameters to consider when choosing a suitable milk replacer are considered below.

Parameter	Farm rearing system	Type of milk replacer
Feeding system	Bucket/pail system	Instant mixing
	Cold ad-lib/ mob feeder	Instant mixing, (acidified required for some systems)
	Semi automatic/ Computer controlled machines	Instant mixing or free flow powder dependant on machine type*
Growth and weaning targets	High genetic merit heifer-accelerated rearing	High protein, higher concentration & feeding level, high daily liveweight gain
	Dairy and beef calves - conventional, early weaning	High specification and often all milk protein
	Beef and dairy calves - conventional, traditional weaning	Good specification with some non-milk protein

Health goals or issues	Coccidosis
	Bacterial diarrhea
	Immuno compromised calves
	Stressed calves
		Added Decoquinate, Lasalocid #
		Added Oxytetracycline, Neomycin#
		High vitamin E levels (150iu/d), Se, Vit C - improve immune response
		Probiotic additives, prebiotic additives, functional proteins, acidifers

* check with machine supplier

approval for use in calf milk repacer and restrictions on use may vary with country. A withdrawal period to slaughter is required and so not suitable for bull calves intended for sale

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Milk Replacer
Evaluation

Top tip

Best evaluation is growth and condition of calves

Reading the feed label/tag

There are statutory details on the label that must be provided according to the legal mandates of the country of origin. These details provide important information when comparing products.

1. **Analytical specification** – provides details of nutrient contribution e.g. crude protein, fat, fibre, ash, vitamins A,D, E and Ca, P. These are minimum or maximum analyzed levels of the milk powder as stated.
2. **Ingredients listings** - are listed in order of inclusion level with highest first (see page 36-37 for groups). Any medication must also be declared with details of use and withdrawal time, if applicable.
3. **Feeding recommendations (mixing and feeding level)** – aim to provide the calf with the correct level of nutrients to meet daily maintenance and growth requirements at thermo-neutral temperature ranges, unless otherwise stated.

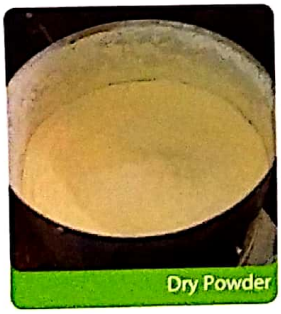
A quick guide to the typical nutrient levels

Nutrient	Range Min Max	Additional information
Protein %	20 27	Higher level for accelerated feeding programs. Conventional powders usually 20-24% CP. Digestibility optimised through good ingredient selection
Fat %	15 22	Provides main energy source alongside lactose that sets growth potential. Must be of high digestibility and ideal fatty acid profile.
Fibre %	0 0.5	Higher levels from inclusion of selected non-milk proteins
Vitamin E mg/kg	50 250	Higher levels more costly but show improved immune function (i.e.150iu/kg or greater)
Selenium mg/kg	0.1 0.3	Maximum is legal maximum inclusion level in complete feed

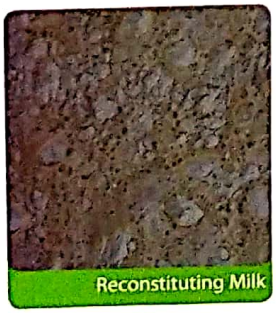
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Feed

Milk Replacer
Evaluation



Dry Powder



Reconstituting Milk

Comparing milk replacer?

Milk replacer can be evaluated in several areas:

- the choice and control of raw materials (structure, colour, smell, taste, etc)
- the formulation, nutritional specification (protein ingredients are generally most expensive)
- the method of manufacture and its quality controls
- the soundness of the feeding nutrition program

Quality ingredients are selected for optimum digestibility, solubility, suspension and stability to enable absorption by the young animal. Most raw materials come in a variety of grades. The standard of excellence in the milk replacer industry is to use food grade, edible raw materials consistent with that used for human consumption. All ingredients must have a very low pathogen status, with no coliforms or salmonella. The ingredients must be palatable and nutritionally meet the physiological requirements of the young growing calf.

Visual assessment

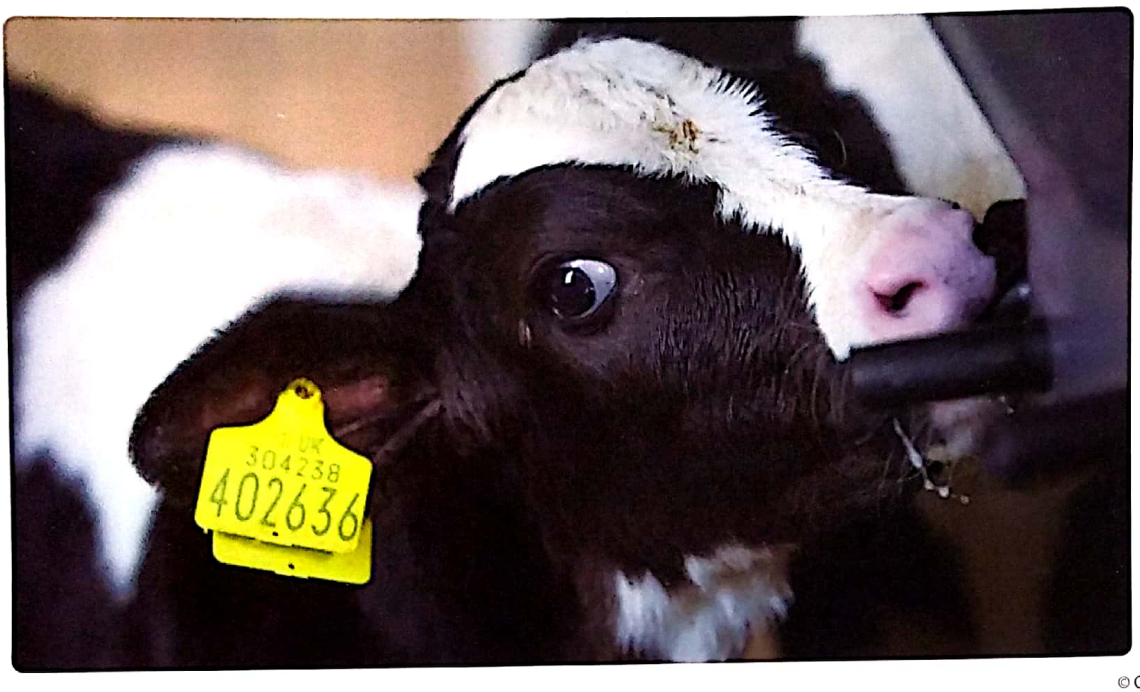
Parameter	Acceptable	Not Acceptable
Dry Powder Colour	Off white, cream to light tan	Orange-brown – heat damage (maillard browning) in storage
Smell	Pleasant, bland	Carmelised smell – heat damage during storage Petroleum, paint, grass, clay – fat may be rancid
Consistency	Free from lumps or foreign material	Large lumps, caking, free-flow not flowing
Reconstituted liquid Colour	Cream to very light tan	Dark, bitty
Smell	Pleasant, milky	Sour milk smell – fat may be rancid or high chlorine, sulphur in water
Taste	Sweet, milky, sweet-tart (acidified)	Off flavour, very bitter, sour
Consistency	Uniform (ingredients in suspension)	Lumps, dark particles, sedimentation

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Milk Replacer
Evaluation

Manufacture of consistent, high quality milk replacer is a very specialized process and must be carefully controlled.



Check list

- ✓ Select MR to suit feeding system
- ✓ Chose spec to suit calf type and growth goals
- ✓ Evaluate quality
- ✓ Ensure mixed correctly
- ✓ Feed at correct level to meet growth targets
- ✓ Store in closed container in cool, dry, well-ventilated area
- ✓ Avoid abrupt change to reduce stress and nutritional scours

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Preparation of Liquid Feeds/Mixing
Explanation

Definition
Procedures and measures to make a suitable liquid feed for the young calf. The process of making a suspension of nutrients in a homogeneous solution

What is it?
Preparation of the liquid feed requires knowledge of five factors

Hygiene Hygiene of mixing and feeding equipment is essential to maintain high quality feed for the calf.

Mixing The technique depends on the feeding system used. It involves both the method of mixing (whisk, machine mixer, automatic machine etc.) and mixing time.

Concentration The amount of dry matter (solid) nutrients contained in the liquid milk. The dry matter concentration of milk solution supplies the calf with a daily quantity of nutrients to support maintenance and growth.

Calves are ideally fed milk solution at a concentration close to maternal levels, 12.5% DM (125g/kg DM). Milk replacer is typically fed between 10-15% DM (100-150g/kg DM) dependent on the rearing system.

Milk Temperature Milk is ideally presented to young animals similar to their body temperature (similar to milk direct from the udder 39.5°C /103.1°F).

Water Temperature The temperature of water used for reconstituting milk replacer affects protein dispersion, fat emulsion and vitamin stability

Milk replacer that is 'agglomerated' during manufacture (fat droplets are encased in protein and lactose), for improved wettability, are best mixed with warm water (40-45°C, 104-115°F). Other milk replacers are better mixed with hot water (60°C, 140°F). See manufacturer's recommendations. Correct mixing temperature ensures a uniform, homogeneous solution with nutrients in suspension and a low fat particle size (<1.5 microns). These factors encourage optimum absorption capacity for the young animal.

Why is it important?
The digestive system of the newborn calf requires that its complete nutrient balance is provided from high quality whole milk or milk replacer. This liquid feed must be presented to the calf at the correct volume, concentration, temperature, quality and nutritional balance to achieve growth potential.

Top tip
Preparation must be accurate and consistent
NOT BY FEEL
or experience

Fact
A badly prepared feed will not provide the correct chemical and physical nutrition causing poor growth and health

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Preparation of Milk Replacers
Application

How to mix milk replacer
The basic principles of mixing are the same irrespective of product and feeding method, only the amount of milk replacer and volume/ temperature of water used will vary.

The specified weight of milk powder must be mixed with the correct volume of water as per manufacturers' instructions. It is important to read recommendations relative to breed, size of calf, feeding system and rearing program.

Bucket/pail feeding systems

Add 1
Put HALF the required volume of warm or hot clean WATER (45-60°C, 110-120°F) into a 'clean' container



Measure 2
MEASURE the amount of POWDER required and ADD TO water by sprinkling on the surface



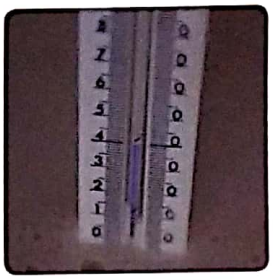
Mix 3
MIX for 3 minutes using a good wire whisk or a paint mixer, to the bottom of container, until smooth and in suspension



Add 4
ADD COOL WATER to make up to required total litres
MIX for 1 minute



Check 5
CHECK TEMPERATURE of milk solution (38-40°C, 100-104°F) using a thermometer and FEED required amount to calf



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Preparation of Liquid Feeds/Mixing
Application

How to mix milk replacer continued

Goal
The correct milk dry matter (concentration) in a drinkable volume produced hygenically

Cool ad-lib feeding systems
Mix (see previous page) in a suitable sized container using water temperature (as recommended by manufacturer).

Typical mixing rate is 125g/litre (5oz/qt).

The feeding container must have a tight fitting lid to keep out flies and dirt.

Ensure thorough mixing and that milk is not fed too cold (<10°C, 50°F) or intake is reduced.

Automatic machine feeding systems
Each machine will vary in the method and amount of milk preparation but milk must be available to the calf at a feeding temperature of 38-40°C.

Mixing temperature is usually 42 - 43°C (110°F) (for cold housing, increasing mixing temperature can help to achieve correct feeding temperature).

Milk solution is often prepared fresh in small portions (e.g. 0.5l) and then pumped to teats. The pump can be calibrated by the machine and alarmed for error.
Milk replacer used must suit the machine i.e. free-flowing or non free flowing. Check with supplier.

Machines with no agitator are not suitable for milk replacer containing non milk proteins, due to separation risks.

Do not over mix by running the machine too long.

It is important to regularly calibrate automatic machines and check finished mix concentration.

E.g. Catch dry powder dispensed in a pre-weighed container and weigh. Catch water dispensed in volumetric jug and calculate concentration.

$$\text{Concentration (g/l)} = \frac{\text{weight (g) of milk powder}}{\text{volume of liquid (l)}}$$

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Preparation of Liquid Feeds/Mixing
Application

Effect of mixing on milk concentration?

The amount of powder and amount of water used will affect the concentration of the finished milk solution.

There are typically two methods of mixing instructions:

1) A weight of milk powder is mixed to make up a volume of solution
2) A weight of powder is added to a volume of water (often automatic milk machines)

A lower milk concentration can achieve the same growth response as a higher concentration if it is fed at a higher level (within appetite limits).

The concentration required will depend on the

- product type/ manufacturer
- feeding method/system (once/twice-a-day, bucket/machine)
- growth targets

See manufacturers' guidelines

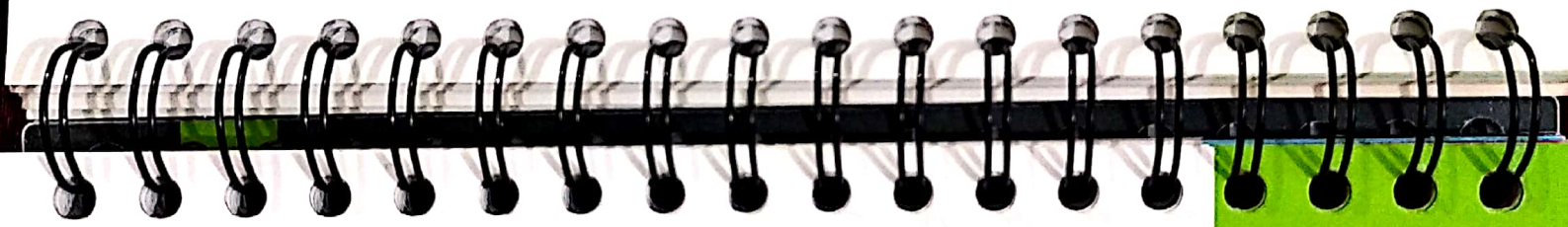
Examples of the effect of mixing method on milk concentration of finished solution

Mixing method	Milk concentration Dry Matter (DM)
Metric	
125 g milk powder ***to*** 1 litre water	12.5%
125 g milk powder **in** 1litre water	11.1%
Imperial (US)	
4oz milk powder **to** 1 quart water	12.0%
4oz milk powder **in** 1 quart water	10.7%

Typical milk concentration for different calf feeding systems

Feeding system	Metric (g/l)	Imperial (US) (oz/qt)
Once a day feeding	150	6
Twice a day feeding	110-125	4
Ad-lib machine	100-130	4-5
Cold-adlib feeding	125	5
Accelerated feeding	150	4-6

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Feed

Preparation of Liquid Feeds/Mixing
Evaluation

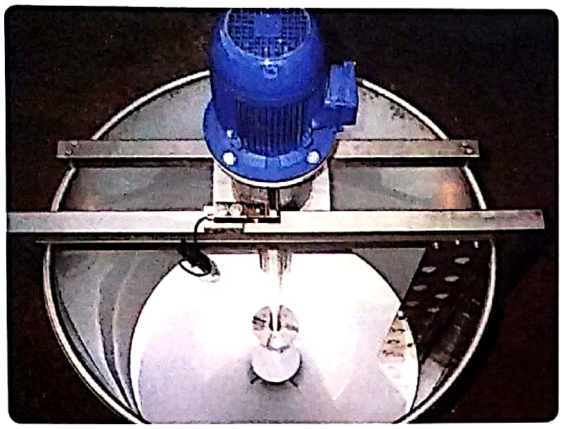
Trouble shooting

Mixing problem	Effect on liquid milk	Effect on calf	Action
Milk powder not mixed correctly/long enough	Milk is lumpy Insufficient pre-treatment of milk Sedimentation (not in suspension)	Feed refusal Digestive problems	Check mixing water temperature Has milk been mixed long enough? Is mixer working efficiently? Is mixer reaching bottom of container?
Mixing too long	Too much air in milk/foaming Effects emulisification of fat Can cause separation of fat forming a greasy layer on surface Negative to vitamin stability & protein dispersion	Increased risk of ruminal bloat Decreased fat digestibility Decreased consumption (stuck to container, nose etc). Poor oesophageal groove reflex	Check mixing time
Water temperature too high (>70°C, 161°F)	Vitamins destroyed Protein denaturing (less soluble, less digestible) Poor emulsification of fats	Digestive disorders Poor performance	Use a thermometer to check water temperature
Water temperature too low (<40°C, 104°F)	May not mix well or need longer mixing Poor dispersion of proteins Incomplete fat emulsion Milk feeding temperature too low	Poor performance Poor oesophageal groove reflex Risk of ruminal bloat Calf not drinking/indigestion	Check water temperature with a thermometer Minimum mix temperature 45°C, 115°F Adjust mix temperature in cold environments Feed immediately after mixing
Poor hygiene	Contamination of milk with pathogens	Poor health and performance Scours, low appetite	Sanitise thoroughly and effectively all feeding and mixing equipment
Incorrect/ inaccurate measures	Concentration too high (oversupply of nutrients)	Poor intake, uneconomic scours potential,	Check weight of powder to volume of water Calibrate regularly
	Concentration too low (undersupply)	Poor growth, health	Use a weigh scale/ volumetric measures

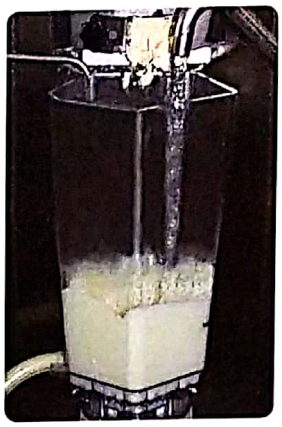
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Preparation of Liquid Feeds/Mixing
Evaluation







Check list

- ✓ Calibrate measuring equipment regularly
- ✓ Weigh milk powder quantity
- ✓ Use 'clean' water at correct volume
- ✓ Check mixing temperature
- ✓ Maintain strict hygiene practises
- ✓ Ensure mixing technique is effective

Fact

Poor preparation leads to incorrect chemical and physical liquid feed resulting in poor growth and health

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Calf Starter
Explanation

Definition
The first solid dry feed that is fed to young calves

What is it?
A high quality complete feed made from grain, protein sources and fortified with vitamins and minerals for feeding to the young calf from 3 days to 12 weeks of age

Why is it important?
Calf starter feed must provide:
- Stimulation for early rumen development
- Presentation and palatability for early intakes
- Balanced nutrition to supplement calves liquid diet for growth, skeletal development and health/strong immune function

Typical calf starter nutrient composition

Energy ME	13.8 MJ/kg 1.5 Mcal/lb
Protein	18-20 %
Fat	3-5 %
NDF	13-25 %
ADF	6-20 %
DUP	0.65 %
Dry matter	12.0 %

See nutrient requirement section for mineral and vitamin recommendations





Top tip!

Dry starter feed consumption is the primary factor in early rumen development

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Calf Starter
Application

What to feed?
Calf Starter feed is formulated to a nutrient specification from a variety of ingredients used to feed adult animals (except urea). There are two types of calf starters: complete starter and grain starter. Complete starter can be formulated with or without roughage products for a higher level of fibre. The importance is to achieve nutrient and physical parameters and maintain a balance of ingredients, economically.

Physical form
Starter feed is best presented as a coarse feed or pellets. Feed processing can have effects on rumen development eg. steam flaked cereals can increase rumen propionate and so papillae development. Ensure starter feed has adequate particle size for proper rumen development. Very finely ground feeds are not recommended as they do not stimulate rumination. Dusty feed is not eaten well and has little impact on rumen development. Starter feed must be highly palatable to encourage early intake.

Goal

Early starter feed intake enables optimum rumen development and weaning transition

Typical feed sources (dependant on availability):

Nutrient	Feeds	Advantages
Carbohydrates	Starch (maize, oats, barley, wheat) Sugar (molasses)	To provide for microbial growth and production of VFA's (e.g. butyrate and propionate-stimulate rumen papillae development) To encourage intake (palatability) and reduce separation and waste (not too high that feed gets too sticky)
Protein	Soybean meal, rapeseed meal, linseed meal, peas etc.	To provide high quality amino acid balance and protein digestibility for the demands of early growth
Fibre	Sugar beet pulp, wheatfeed, grassmeal , dried brewers grains etc.	To provide digestible fibre for rumen development and stimulate intakes. It is not necessary to feed additional forages until after the calf is weaned
Minerals & Vitamins	High quality, balanced premix	To ensure optimum health and feed utilisation. B-vitamins are added to supplement the developing rumen
Additives	Coccidiostats, Probiotics, Prebiotics	Improved performance, health etc.



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Feed

Calf Starter
Application

When to feed?
Offer calf starter from 3-5 days of age and until about four months of age (six to eight weeks post weaning).

The 'Rearer' feed will depend on desired performance, rearing program and quality of forage available.

How much to feed?
Individual calves will have a large variation in dry feed intake (breed, size, age, health differences).
The ability/desire to consume dry starter feed is in direct proportion to the volume of liquid feed being offered.
Daily weight gain has a positive effect on dry matter intake.

Pre-Weaning period From 3 days age, offer starter feed in small amounts. Increase level gradually to achieve weaning minimum of 1kg calf starter/head/day

Post Weaning Offer on ad-libitum basis
Intake increases gradually as calf grows.
Change onto rearer feed when eating 2.5-3.0 kg/h/d (3-4 months of age)

How to feed?
Encourage early intake of starter feed intake by:

- Placing a small amount of starter feed, by hand, in the calf's mouth after their milk feed
- Provide starter feed daily on an ad-lib basis and ensure it is fresh and dust- free
- A shallow bowl allows the calf to lick the bottom
- Keep feed containers clean (daily) and free of wet compacted material
- Remember - Wet feed provides a favourable environment for mould growth, particularly in warm, humid and damp weather
- Always ensure adequate fresh, clean water is available as soon as starter feed is offered



Fact

Intake of dry feed is positively influenced by water consumption

Guide

Water to starter ratio is usually 4:1 (1kg starter requires 4 kg water intake)

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Calf Starter
Evaluation

Summary of calf starter management

Factor	Considerations
Feed ingredients	Only use high quality ingredients that are palatable, nutritionally sound and free of contaminants. Ensure texture and particle size is sufficient to help stimulate rumen function and development. Dusty feed and mouldy feed is detrimental to feed intake and health. Store feed in a dry covered bin to limit moisture and access to birds and rodents.
Feed quantity	Feed small amounts to youngest calves, offering more as appetite increases . Feed weight per unit volume (bulk density) can change with feed type/batch and conditions. Only wean when starter intake is adequate (1kg for 3 consecutive days). Hot weather environments (heat/humidity) can reduce daily intake, affect rumen development and age of weaning.
Feeding equipment	All feeding equipment must be cleaned and sterilized before each use. Dirty, contaminated equipment can easily introduce and spread unwanted pathogens. Feeding equipment must be in good condition and appropriate for animal being fed. Eg. bowl size, height from floor etc.
Feeding routine	Feed regular amounts of feed at the same time every day Hungry calves eat quickly and often over-eat, leading to changes in digestion. Check position of feeding vessels and that they are easily accessible.
Water	Adequate, fresh, clean water should be readily available. Microbial contamination of water will enter the animal and may encourage bloat causing organisms. 'Free' water (not provided by milk feed) is necessary for proper rumen development and function. Ensure water and calf starter are separate to avoid wet starter feed and dirty water.
Stress	Management and environmental changes often lead to stress. Feed changes, weather changes etc, can lead to stress and health challenges. Gradual change causes less stress, maintaining healthier, growing calves Do not move calves for 2 weeks after weaning and then group according to weight/ size.

Check list

- ✓ Feed only the highest quality starter feed
- ✓ Ensure ingredients suitable for digestive capability and rumen developement
- ✓ Consistent supply to all calves
- ✓ Feed in sanitized containers
- ✓ Store feed appropriately to maintain feed quality
- ✓ Know weight of feed fed not volume

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Water
Explanation

H_2O

What is it?
Water is an essential nutrient for most plant and animal life. It accounts for 70-75% of young animal's body weight and yet, is often overlooked as a necessary nutrient.

Where does it come from?
An animal obtains its water from drinking water, water present in its food and metabolic water.
Calf unit water supplies are used for drinking water, mixing milk replacer and for washing equipment etc.

Why is it important?
The calf has a daily requirement for water for:

Basic metabolic functions- Require a daily water intake to replace that which is continuously being used or eliminated. Eg. Transporting nutrients (blood volume), excretion of waste products (urine and faeces), digestion of feed, maintenance of osmotic pressure, lubrication of joints and eyes, exchange of CO^2 with O^2 in the lungs, regulation of body temperature.

Bacteria in the rumen- They can only survive in a water environment. Most of the water that enters the rumen is from free water intake. Milk or milk replacer do not constitute free water as they bypass the rumen due to the esophageal groove that can be active until 12 weeks of age.



Dry feed intake- It is stimulated by 'free' water intake and promotes greater total feed intake. This helps rumen development and rumen fermentation which results in more energy for maintenance and growth. This leads to improved performance and health.

Excessive water loss by the calf (e.g. scours or hot, humid weather) or from water restriction (ice, dirty water, inadequate supply) results in a reduction in body fluid, dehyrdration. This negatively impacts metabolism and feed intake.

Fact
Insufficient water ▸ slower rumen development

Insufficient water ▸ reduces feed conversion rates

Fact
Calves perform best with 'free' water available from birth

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Water
Application

What type of water?
- Clean water - water can become contaminated with chemicals, microbial organisms, high levels of minerals etc. that could be detrimental to young animals, affecting their health and/or growth
- Cool water (10°C) is best for performance because it helps the animal get rid of excess heat (calves cannot sweat but need to stay cool)
- In cold conditions, warm water will reduce 'cold load' on the calf and increase time to freezing

How much water?
- Water intake during 1st week of life can be approximately 1 litre per day (NRC, 2001)
- Water requirements increase exponentially as the environmental temperature rises; as it approaches 32°C (90°F), requirements increase dramatically
- Calves may consume more water because they are still hungry (i.e.) not getting enough energy from the milk and this will lead to poor growth and performance
- Adequate water (approximately 4.5litres/kg DM intake) provides efficient conversion of feed into weight gain.

How to provide water?
- Via clean bucket/pail or other suitable cleanable container (separate from grain)
- Via an automatic system
- Ensure sufficient accessibility so as not to limit intake
- Separate feed and water pails for improved intake

How to maintain ?
- Action a regular maintenance and cleaning routine to maintain hygiene and adequate flow/ supply
- Dirty vessels, contaminated nozzles and pipelines may encourage bacteria and fungi to grow
- Ice conditions require vigilance in maintaining water availability to the calf

Typical calf water requirements

Age (mths)	Litres	Gallon
1	5-7.5	1.3-2.0
2	5.5-7.5	1.5-2.0
3	8-10	2.1-2.6
4	11-13.5	3-3.6

Top tip!
Provide enough, fresh, clean, cool water daily.

Guide:
4.5litres per kg DM intake



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Water
Evaluation

Water quality:
There are five key properties in evaluating water quality:
- physiochemical properties
- presence of toxic compounds
- excess minerals or compounds
- organoleptic properties
- microbial contamination (bacteria and algae).

Water quality testing is an important tool to ensure that water sources used for the calf will not have a detrimental impact on intake, nutrition, and health.

Maximum recommended levels vary with source of information, highlighting the level of uncertainty in some areas. Limited data is often available including the bioavailability of the chemical form present and the effects on animal performance. Also, additive or interactive effects of increasing levels of multiple substances in the water may have an effect on animal performance.

Salinity is often used as a convenient guide to the suitability of water for livestock as it affects palatability and consumption. Salinity is a measure of the concentration of dissolved salts, TDS, predominantly calcium, magnesium and sodium chloride If water has a laxative or toxic effect, TDS concentration should be analysed.

Bacterial contamination of the water source could provide sufficient bacterial load to cause disease in young animals. Warm milk replacer, reconstituted with dirty water can provide an ideal medium for rapid bacterial growth.

Water analysis is suggested for all water systems , at least yearly.

Particular attention should be paid to well water sources and especially after snow has melted, heavy rainfall and excessive run-off situations.

An extensive list of recommended maximum concentrations for selected chemicals and micro-organisms in livestock drinking water are tabulated in the following pages.

Water quality analyses would be useful expressed as 'total maximum daily load. This would present a dose risk more accurately and would enable interpreters to consider the effects of a specific element from all sources, ie. feed and water.

Check list
- ✓ Know water quality supplied for calf use
- ✓ Maintain and sanitise vessels regularly
- ✓ Ensure enough, fresh, clean water is available daily
- ✓ Separate water and feed vessels
- ✓ Monitor calves regularly
- ✓ Monitor weather and its potential effects on water supply

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Water Analysis

Maximum recommended concentrations for selected chemicals and micro-organisms in livestock drinking water.

Chemical Name	Symbol	Guideline	Units	Comments
Acidity / Alkalinity	pH	6.5-8.5	pH units	Guideline values. If pH is lower than 5.5, acidosis and reduced feed intake may occur in cattle. Chlorination efficiency is reduced at high pH. A low pH may cause precipitation of some antibacterial agents delivered through the water system (for example sulphonamides). Veal calves target: 6.8-7.3.
Alkalinity	as $CaCO_3$	500	mg/l	Alkalinity levels above 500 mg/L can have a laxative effect. Lower levels may have a laxative effect if sulphate is present in the water.
Aluminum	Al	0.5	mg/l	Upper limit guideline for cattle.
Arsenic	Ar	0.05	mg/L	
Bacteria - total bacteria - total coliform - faecal coliform - faecal strep.		<10,000 0 0 0	Counts/ 100 mL	Guideline values are for calves. If pollution is from human wastes, faecal coliforms should exceed faecal strep by several times. If pollution is from an animal source, strep should exceed coliform
Boron	Bo	5	mg/L	
Cadmium	Cd	0.005	mg/L	
Calcium	Ca	700	mg/L	Guideline value when magnesium is present
Calcium	Ca	1000	mg/L	Guideline value when magnesium is absent
Chloride	Cl	250-1000	mg/L	>250ppm can cause brackish taste that may result in low water intake. Veal target <5ppm.

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Water Analysis

Feed

Maximum recommended concentrations for selected chemicals and micro-organisms in livestock drinking water.

Chemical Name	Symbol	Guideline	Units	Comments
Chromium	Cr	0.1	mg/L	Guideline max for cattle 0.1ppm(NRC), 0.05ppm (U.S.EPA)
Cobalt	Co	1.0	mg/L	Guideline value. Cobalt is an essential trace element and toxicity symptoms are not likely to become apparent until levels are an order of magnitude higher than the recommended level.
Copper	Cu	1.0	mg/l	Guideline value for cattle. Copper is essential to animal health and is often a feed additive. Revise levels downwards if supplements are given if feed is high in copper. (0.5mg/l recommended)
Fluoride	F	2	mg/l	Guideline value, but mottling of teeth may occur at this level. If fluoride is included in feed, concentration should not exceed 1 mg/L.
Hardness (as $CaCO_3$) - Soft - Moderately hard - Hard - Very hard		0-60 61-120 121-180 >180	mg/l	Hardness has no effect on water safety, but can result in the accumulation of scale in water delivery pipes. The scale mainly consists of magnesium, manganese, iron and calcium carbonates. Water with less than 120 mg/L as $CaCO_3$ is ideal.
Iron	Fe	0.3	mg/l	No toxicity guideline established. Veal calves will have increased colouration of meat at iron levels as low as 0.1 mg/; this level can also give milk an oxidized flavour. Iron can present problems in restricted flow drinking water lines where iron precipitation may plug the line. It can also present problems when water is disinfected and can encourage bacterial slime growth in water supply lines.
Lead	Pb	0.015	mg/l	Cattle guideline value. Lead is cumulative. Chronic lead poisoning may occur at levels of 0.5 to 1.0 mg/L.

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Water Analysis

Maximum recommended concentrations for selected chemicals and micro-organisms in livestock drinking water.

Chemical Name	Symbol	Guideline	Units	Comments
Magnesium	Mg	50-100	mg/l	30mg/L suggested for veal calves. Magnesium forms part of the hardness in water.
Manganese	Mn	0.05	mg/l	No toxicity guideline established. Manganese together with iron will discolour fixtures. Manganese and iron can present problems in restricted flow devices in drinking water lines where manganese precipitation may plug the line. Manganese will also present problems when the water is to be disinfected. Can also have an adverse effect on taste. Target 0.02mg/l for veal calves.
Mercury	Hg	0.01	mg/l	Heavy metal, not desirable.
Molybdenum	Mo	0.05-0.15	mg/l	Guideline value. An essential element, but it is toxic (linked to intake of copper sulphate. Cu: Mo ratio of 2:1 will prevent poisoning. Sheep, swine and poultry are more tolerant than cattle to poisoning. The lower level suggested.
Nickel	Ni	0.25-1.0	mg/l	
Nitrate	NO_3	0-45	mg/l	Guideline value. Nitrate may impair the oxygen-carrying capacity of the blood by nitrite reducing haemoglobin to methemoglobin. Ruminants are more sensitive than monogastrics because of the ability of the rumen microbes to reduce nitrate to the more toxic nitrite. Often indicates bacterial contamination or contamination from runoff water from land that has received heavy application of fertilizer. Reduced gains, milk production, reproductive problems. Take care that comparing analyses are same. (I.e) 10mg/l nitrate equivalent to 2.3mg/l nitrate-N. Human max. Nitrate-N is 10mg/l
Nitrite	NO_2	10	mg/l	Guideline value. More toxic than nitrate. Nitrite may impair the oxygen-carrying capacity of the blood by reducing haemoglobin to methemoglobin. Animal suffocates. >4mg/l maybe toxic to cattle. Nitrite-N human max 1mg/l (3.3mg/l Nitrite). Veal target 0-0.1mg/L

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Feed

Water Analysis

Maximum recommended concentrations for selected chemicals and micro-organisms in livestock drinking water.

Chemical Name	Symbol	Guideline	Units	Comments
Phosphate	total P	0.7-1	mg/l	Guideline value. In surface waters, phosphate is typically a limiting plant nutrient. Human max. recommended is 0.1mg/l.
Potassium	K	10	mg/l	Contributes to alkanity and in its chloride form contributes to TDS test. Can affect taste and corrosivity.
Selenium	Se	0.05	mg/l	Guideline value. An essential element, but at high levels can be toxic.
Sodium	Na	50	mg/l	Contributes to salinity and TDS. Can affect taste and corrosivity. Target veal 20mg/l.
Sulphate	SO_4	500	mg/l	Target for veal calves 3mg/l. High levels may induce trace mineral deficiency.
Sulphide	H_2S	<1.0	mg/l	This is not a toxicity guideline, but a taste and smell advisory. High levels may increase problems with anaemia and those related to Cu, Se and Vit E nutrition.
Total dissolved	TDS	<1000 1000-3000 3000-5000 >5000	mg/l	A relatively low level of salinity and should present no serious burden to any class of livestock Should not affect health and performance. Satisfactory for all classes of livestock, may cause temporary and mild diarrhoea in livestock not accustomised. Not ideal as can cause temporary diarrhoea or be refused at first by animals not accustomised. This water is unfit for calves.
Vanadium	V	0.1	mg/l	
Zinc	Zn	5-25	mg/l	Guideline value. This is an essential element for livestock, but at high levels it can exert toxicity. The lowest recorded effect was at 20 mg/L where the rumen microbes in cattle were affected (decreased digestion of cellulose).

Notes- Information from CCREM 1987, Australian Water Quality Criteria 1974, NAS 1974, CAST 1974, BCMOELP 1994, NRC 1974, NRC 1998, NRC 2001, NRC 2005 Manitoba Agriculture 1992, 2006, EPA 1996, CPAQ 1999, Agriculuture and Agri-food Canada, 2000, Socha et al, 2003.

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Section 3

Calf Rearing Guide — Practical and easy to use

Management

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Liquid Feeding Systems

Explanation

Definition
Methods of providing liquid milk to calves.

What types are there?

Restricted feeding
ONCE PER DAY
Bucket/Pail – open or via teat
1



Restricted feeding
TWICE A DAY
Bucket/Pail – open or via teat
2



Ad-lib feeding
COLD
Ad-lib feeding system/ Mob feeders
3



Ad-lib feeding
WARM
Automatic machine/ Computer controlled feeder
4



Why is it important?
Calf growth during the milk-feeding stage is the most expensive per unit of feed and so must be done effectively and efficiently to meet producer targets.

The method of feeding calves must be suitable for:

1. The housing facilities available
2. Services available i.e. water supply, power supply, storage space
3. The number of calves being reared
4. The labour and level of stock personship available
5. The rearing targets e.g. growth, development, weaning age

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Liquid Feeding Systems
Application

Restricted feeding systems
- Calves are fed limited amounts (4-6 litres/ day) of liquid milk twice or once a day, at the same time each day
- These systems were developed to encourage the calf to eat more starter feed at a younger age, limiting the costs of milk versus grain
- Twice a day is more popular than once a day; it is more flexible and allows for good supervision of animals
- Additional viewing of the calves, other than at feeding times, is important to check for signs of illness.

Housing/ management
- Calves are individually penned and fed via an open bucket/pail or via a teat attached to a bucket/pail
- Milk from a teat encourages a more natural drinking behaviour
- Pails should not be fed at ground level. Ensure the bottom of the pail is approx. 12" (30cm) from pen bedding level
- Pail must be angled to encourage neck extension and effective oesphageal groove closure
- Calves may require a period of training to ensure that the calf drinks well
- Sometime three feeds a day are required, e.g. accelerated feeding systems, cold winter feeding
- This system is not dependant on external power or mechanical gadgets. Access to hot water is required for mixing milk replacer.

Feeding method
Once a day:
- Calves are fed one liquid feed every 24 hours
- If using milk powder concentration typically 15% (150g per litre of water)
- Effective where average to low growth rates are required (300-400g/d)
- This system has a low labour input.

Twice a day:
- Calves are fed liquid feed twice every 24 hours, at the same time each day
- Milk powder concentration typically 10-12.5% DM
- Suitable for calves requiring a medium growth rate to weaning (400-500g/d)
- System is more flexible than once a day.

Three times a day:
- Calves are fed liquid feed three times every 24 hours
- Suggested for accelerated/enhanced feeding programs to achieve the high DMintakes required for high growth rates (700-800g/day)
- Also used in cold environment conditions where extra feed energy is required to maintain calf body temperature and thermo-neutral zone.



Neck extension - important for effective oesphageal groove closure

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Liquid Feeding Systems
Application
Management



Ad-Lib feeding systems
- Calves are provided milk on a continuous basis throughout the day
- These systems were developed to reduce labour demand and encourage higher rates of gain and feed conversion
- They also mimic nature more closely
- Milk powder concentration is typically 10-12.5% DM
- The amount of liquid feed consumed is higher than on restricted systems and so cost of feed is higher
- Growth rate is higher than on restricted feeding systems
- Ideal for dairy farms, bull calf rearing and calf fattening units.

Housing and management
- Calves are generally housed in groups
- Housing design is important and the control of areas such as extra urine, wet bedding
- Self feeding systems need very diligent calf observation and hygiene procedures
- The system must suit farm limitations and production requirements
- Calves spend about 45 minutes drinking milk each day, compared to just a minute or two when restrict fed. This can provide a natural outlet for sucking behaviour
- A planned weaning management is required to avoid large growth checks at weaning

Feeding method
Cold ad-lib feeding/mob feeders:
- Milk is prepared and provided in large containers that is then fed, via tubes to a teat/nipple feeder system. This allows several calves' access to liquid milk at the same time
- Milk is fed cool to avoid gorge feeding
- The number of nipples/teats will depend on the size of the container and number of calves, one teat per 7-8 calves is suggested
- There are no controls on which calves drink and how much they take
- There is no automatic washing of the teat between calves
- It is important to maintain a regular and effective cleaning and disinfection schedule
- Milk in the container is subject to surrounding environmental temperature. Too cold and intakes will reduce, reducing growth rate
- If milk is maintained at a warm temperature for an extended period, bacterial growth may dominate
- Acidification can be used to preserve milk for storage at room temperature
- The advantage of this system is its simplicity, low cost and ease of use
- A power source is not required

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Liquid Feeding Systems
Application

Ad-lib feeding systems continued

Semi-automatic, ad lib machine feeding:

- Liquid milk is delivered to the calf at a set, consistent temperature for consistent results
- Milk replacer is mixed with warm water at a set rate.
- Care must be taken to ensure that the finished concentration of the liquid milk is correct and consistent.
- Calves are fed via a teat with a self closing hole
- Teats should be at least 1.0m (3ft) apart and 60-80cm from the ground (calf size dependant). One teat per 7-8 calves.
- Calves must be grouped by age and weight
- A power supply and water supply, with backup is required
- There is a capital cost depending on type of machine but this can be compared with cost of individual pens/hutches and pail/bucket cost etc
- Some machines have a self cleaning facility that provides an easy way to maintain sanitation of the unit and nipple feeders

Computer controlled machine feeding:

- Calves wear a transponder (ear tags or collar) that responds to a sensor at the milk feeding point. (See beside)
- Computers identify the calf within a group, the machine dispenses a controlled amount of feed, a controlled number of times in the day
- Milk powder is stored in a hopper and usually a free-flow powder is required
- Milk is freshly prepared for calves at set concentration and optimum temperature (mixed at 40°C, feed at 37°C)
- Feeders generally have the capacity to feed between 15 and 60 calves at any one time, usually 25 calves per feeding station
- Feeders can provide computer analysis of individual or group of calves. This may include data storage, traceability, information on drinking behaviour of individual calves etc. Individual medication, electrolyte administration programs are also available
- Automatic wash/rinse system operates, some with self cleaning nipple station option, improving hygiene controls
- Capital cost is high but for large groups of calves this can be offset against labour and performance savings
- Future applications with automatic group feeders may include: fever measurer, measuring water amount, individual allocation to match weight, size etc





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Liquid Feeding Systems
Application

Management

Accelerated/ Enhanced feeding systems

- A system of feeding young calves principally developed in the USA to more accurately define nutrient requirements of Holstein cattle from birth
- Aimed to maximize growth potential of high genetic merit heifers to achieve frame and growth required for 2 year calving
- The diet and feeding levels optimize milk protein utilization for increased bone and muscle growth without excess fattening
- Added advantages include a higher feed efficiency of gain and enhanced immune function.

Housing/management

- Calves are housed individually or in groups
- Calves can be fed via bucket or machine
- A high level of management is required as higher rates of feeding may increase nutritional scour cases
- Weaning management is important to ensure sufficient rumen development
- Changes in management of older calves and heifers may be required to ensure the benefits are optimised for the long term.

Feeding method

- Calves are fed more total solids per day (800-900g) of a specially formulated high protein milk replacer (26-27%)
- High protein is required to match (and make use of) the higher energy intake and so optimise the allowable growth
- Minerals and vitamins are also balanced for the higher level of intake
- Typically milk powder concentration is 15% DM (150g/l)
- A higher protein calf starter (22-24% DM) is required to compliment and maintain growth levels.





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Liquid Feeding Systems
Evaluation

Practical assessment of bucket/pail and cold ad-lib feeding systems

System	Pros	Cons
Bucket/Pail	Calves checked regularly Controls on volumes fed and so cost of feed Does not require power supply Can be used for all types of liquid feed Calf encouraged to eat starter feed Individual weaning Can be fed via teat or bucket Individual pen gives control on health, disease etc	Limited feed can limit performance Requires planned feed selection and amount fed to meet growth targets A lot of equipment per calf and to keep clean Labour intensive Time consuming and time dependant (feed at same time each day) Building space required will be more than group systems
Cold ad-lib	Low cost set up Group feeding, reduced labour Does not require power supply Can be used for all types of liquid feed Good performance from high intakes	No control on amount of milk each calf consumes High supply of milk/milk replacer required, Can be difficult to maintain strict sanitation Can limit starter feed intake High level observation and weaning management skills Cold environments impose management problems and potential for reduced growth High level observation and weaning management skills



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Management

Liquid Feeding Systems
Evaluation

Practical assessment of automatic feeding systems

System	Pros	Cons
Semi-automatic machine / warm ad-lib machine	Calf receives consistent milk supply Milk/milk replacer supplied at consistent temperature Labour saving Can have self clean facilities for sanitation High growth rates and feed conversion rates High plane of nutrition Suitable for any number of calves	Requires power and water supply Capital cost of machine High supply of milk /milk replacer required, High level observation and weaning management skills Must maintain strict daily sanitation Calves may require training
Computer controlled machine	Control of feeding programme to calf/farm objectives Can adapt to changes in farm requirements, e.g. calf numbers, medication, feed type etc. Self cleaning facility for sanitation Individual weaning with minimal set backs Instant access to daily feed consumption of each calf Low labour with feed cost control of a restricted system High growth rates and feed conversion rates	Requires power and water supply Capital cost of machine Good observation management skills



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Liquid Feeding Systems
Evaluation

Economic assessment of liquid feeding systems

Feeding system	Typical housing	Labour requirement		Amount milk powder to 8 weeks (kg/head)*	Capital cost	Management level
		Rating	Approx man hours/calf			
Pail - twice a day	Individual pens/ hutches	Highest	1.9	28	Medium	Low
Pail - once a day	Individual pens/	High	1.18	25	Medium	Medium
Cold ad-lib	Group	Medium	0.68	40	Low	High
Semi-automatic Machine	Group	Low	0.33	50-55	Medium	High
Computer controlled machine	Group	Low	0.33	30	High	Medium
Accelerated feeding	Individual/Group	High	-	40	Medium	High

* Amount will depend on calf liveweight entering the unit, weaning age, feeding rate and mixing rate (concentration of milk replacer).

Check list

- ✓ Suitable containers/ system to feed regular liquid milk to calves
- ✓ Suitable containers for water and calf starter
- ✓ Suitable feed program for chosen liquid milk to meet growth targets
- ✓ Trained, consistent, personnel
- ✓ Strict hygiene procedures
- ✓ Detailed observation of calf behaviour and condition

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Feeding Programs
Explanation

Definition
A plan of activities and actions to provide calves with their food supply to meet growth, health and economic targets.

What is it?
The feeding program consists of:

The Feed Schedule
- Sets out the timing of feeding and the daily amount of milk to be fed from birth until weaning to meet growth targets
- The schedule can be on a daily or weekly basis dependant on the age of the calf, the feeding system and any management constraints.

The Feeding Routine
- Describes the duties to be done regularly or at specified intervals to achieve successful feeding.

Feeding programs will vary dependant on:

Calf	Breed/genetics, age, size, number
Liquid milk feed	Type(s) available and feeding system
Farm	Housing (group/ individual), environmental effects etc.

The feeding program must be easy to follow and suitable for the farm rearing system.
The feeding program must be monitored regularly and be adaptable to change if required.
Any changes to the feeding program must be done with judgment and care.

Why is it important?
Each calf producer will have targets for growth, health and economic performance.
The feeding program is developed to ensure these targets are met and minimize stress.
The feeding program provides standards and consistency to optimise growth and health.



Top tip!
Consistency and attention to detail reduces stress and encourages healthy, well grown calves

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Feeding Programs
Application

What is a feeding schedule?

The calf feeding schedule follows a timeline from birth (or arrival of purchased calves) to weaning and typically provides details on:

- The type of feed(s) required by the calf
- The daily amount of each feed required per calf
- The number and timing of feeds per day

This information can also be presented as amount per group or mixer capacity etc. to suit the calf rearing unit.

The feeding schedule timeline will depend on the weaning objectives.
Typical timeline for homebred calves is shown below for bucket/pail rearing, that aim to wean at 8 weeks of age, (purchased calves start program at day 4).
For earlier weaning programs, start the weaning process earlier, if starter intake and rumen development is sufficient.
Introduce all feed gradually and monitor intake.
Feed levels must be adjusted to suit calf size, growth targets and environmental temperature changes.

Feed	Day 1	Day 2-4	Day 4-14 (wk 1-2)	Day 15-42 (wk 3-6)	Day 42-49 (wk 7)	Day 49-56(wk 8)
Liquid milk feed	High quality colostrum as soon as possible	Introduce regular liquid feed	Feed liquid feed Increasing gradually over first week	Feed liquid feed according to chosen feed program	Start weaning process, reduce milk feed by 25-50% to encourage calf starter intake	Stop liquid milk feed when calf meets weaning criteria (see weaning)
Calf starter			Ad lib fresh daily	Ad lib fresh daily	Ad lib fresh daily ensure sufficient available	Ad lib fresh daily Calf eating 1 kg/day for 3 consecutive days
Water		Encourage drinking by offering 20 mins after milk feed	Ad lib fresh daily Typically 1-2 l / day	Ad lib fresh daily	Ad lib fresh daily	Ad lib fresh daily

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Management

Feeding Programs
Application

Example liquid feed schedules for restricted-feeding systems

Twice a day feeding schedule for 45kg calf (100lb)
125g/litre for 0.5-0.6 kg daily live weight gain

Calf Age	Milk fed (litres) a.m	Milk fed (litres) p.m.	Milk powder# (gram/day)
Day 1	*	*	*
Day 2-4	1.0/1.25	1.0/1.25	300/350
Day 5-7	1.5	1.5	375
Week 2	2.0	2.0	500
Week 3	2.5	2.5	625
WK 4-6	3	3	750
Week 7	3		375
Week 8	2		250

* Colostrum 4 litres within 2 hours births and 2 litres more within 6-8 hrs.

Once a day feeding schedule for 45kg calf (100lb)
** 150g/litre for 0.4 kg daily liveweight gain.

Calf Age	Milk fed (litres) a.m	Milk fed (litres) p.m.	Milk powder** (gram/day)
Day 1	*	*	*
Day 2-4	1.5	1.5	300
Day 5-7	1.75-2.25		262.5-337.5
Week 2	2.5-2.75		375-412.5
Week 3	2.75		412.5
Weeks 4-6	2.75		412.5
Week 7			
Week 8			

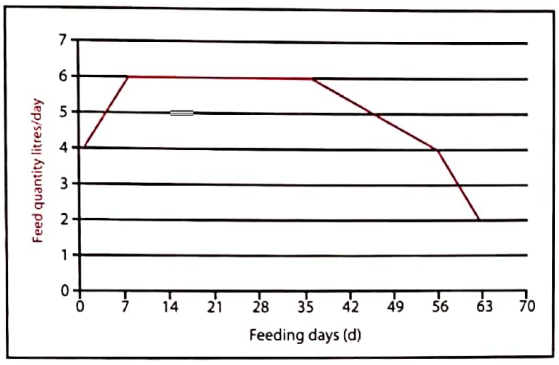
* Colostrum 4 litres within 2 hours births and 2 litres more within 6-8 hrs.

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Feeding Programs
Application

Example feeding schedule for automatic feeding systems



Most micro-processor controlled machines are programmed to work from 'days on the machine' and not 'age of calf'.
It is advisable to know the concentration of any previous milk feed to ensure a gradual change if very different to the machine concentration.
Automatic machines can be programmed by time periods to control various management options including:

- Concentration of reconstituted milk replacer – e.g. 130g/l #
- Number of meals per day
- Amount of milk fed per day

for cold barns (a non-insulated barn and where average daily indoor temperature is <5°C) the concentration of the milk can be increased to 135g/l to ensure higher energy requirements are met.
Individual calf intake in group fed calves can be difficult to monitor. It is best to have even groups and monitor condition alongside average intake calculations.
Consult with milk/ machine supplier for suggested concentrations.



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Management

Feeding Programs
Application

How much to feed?

The total daily amount of milk solution fed depends on the nutrient requirements of the calf (weight of calf and growth targets) compared to the nutrient balance of the milk feed and starter feed (if applicable). This can be affected by stress periods, including cold temperature environments, poor health etc.

Typical liquid milk consumption

Feeding System	Amount per day % of bodweight
Restrict fed	10-12
Accelerated	14
Ad-libitum	15-24

The 'amount of milk solution per feed' depends on the feeding system being used (i.e.) once a day, twice a day, accelerated, ad-lib etc
The milk feed can be offered on a 'step-up/ step-down' schedule or a fixed daily amount for the milk feeding period.
Meal size must suit animal digestion and be within appetite and management limits, to avoid digestive upset.
During cold weather environments, when additional milk is required, often an extra feed rather than increasing amount of individual feed, avoids digestive upset

Calf starter and water should be available on an ad-libitum basis, with fresh supplies provided daily. The amount taken will increase as the calf grows.

When to feed?

The number and timing of feeds per day will depend on the feeding system (once a day, twice a day, adlib etc) and the management capabilities of the calf unit.
It is important to feed at a regular time each day
Consistency is important to reduce stress.

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Feeding Programs
Application

Management

What is a feeding routine?
Feeding routine includes the daily and weekly regular duties required for successful rearing and will be dependant on the rearing unit and calf feeding system.

Typical daily duties:
- Preparation (concentration, temperature, volume) of fresh liquid milk feed at each feeding time
- Consistent presentation of feed to calf, e.g. bucket/pail, nipple feeders etc
- When to provide the liquid milk feed, water and calf starter
- Consistent personnel feeding calves
- Observation of calves during the day for feed refusals, stool consistency, signs of illness etc
- Cleaning and sanitation of all feeding equipment and utensils (utensils, mixing and feeding vessels, water bowls, milk lines)

Regular duties:
- Maintenance of feeding equipment (physical and mechanical)- weekly
- Calibration of weighing equipment/ automatic feeding machines – weekly or with change in milk replacer batch or brand
- Monitor water quality
- Monitor health and hygiene



Goal
- Consistency
- Observation
- Attention to detail

Management

Feeding Programs
Evaluation

Trouble shooting

Performance Parameter	What to check?	Action
Inadequate calf growth (Insufficient nutrients to meet requirements)	Concentration/mixing technique/ quantity of feed offered	Ensure mixing technique and concentration is accurate for MR. Check feed schedule is correct for size of calf and growth rates required . Check the volume/weight of feed consumed.
	Quality of feeds	Check composition and quality (fat, protein) of feeds can meet growth targets.
	Environment conditions	Adjust feed schedule in advance of cold environment conditions.
Poor health (Insufficient Ig, immune response)	Colostrum quality, quantity and timing	Review colostrum management.
	Nutrient intake	Ensure calf is not underfed and is able to support immune function.
(Poor hygiene)	Bacterial contamination of feed Housing pathogen exposure, dirty calves	Review hygiene management of feeding and equipment Review housing management, ensure calf has sufficient dry bedding.
	Health status/ sub-clinical disease	Manage ventilation, humidity, dampness, temperature, animal density, drafts Isolate sick calves and treat as soon as possible
Poor economics	Liquid feed Weaning age and success	Check it is suitable for rearing system and growth targets Check feed program can meet farm objectives for weaning etc. Monitor calf rearing unit to ensure targets are being met

Check list
- ✓ Compose feed schedule and feeding routine for growth targets
- ✓ Know start weight of calf
- ✓ Feeding schedule is a guideline
- ✓ Be clean and consistent
- ✓ Monitor calf regularly for growth & health
- ✓ Pay attention for signs of sickness
- ✓ Adjust plans to maintain growth targets

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Weaning
Explanation

Definition
The process of transferring a calf from a liquid-milk diet to a solid-based diet and maintaining growth, performance and health.

What is it?
It is the stage of calf rearing when the rumen has achieved adequate physiological development so that the calf can support its nutritional needs from rumen fermentation and digestion of dry feed.
Grain starter feed stimulates early rumen development (see rumen development from page 6).
From the first time that grain starter feed is fed, it takes a minimum of 3 weeks to develop rumen papillae.

Why is it important?
Weaning allows the producer to reduce feed and labour costs compared to liquid fed calves.
Producers must decide farm weaning targets and assist the calf as much as possible to achieve them.
Early weaning requires good management practices and can provide good economics.

Planned weaning systems
- Optimize **G**rowth potential pre-weaning
- Encourage **R**umen development
- Maximize **E**conomic rearing value
- Minimize **W**eight-loss at weaning (weaning stall-out)



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Management

Weaning
Application

What to feed?

Liquid Milk Feeds
High quality milk feed is required to provide the nutritional needs of the young, growing calf . Prior to weaning, liquid feed is provided in restricted amounts to encourage increased starter intake.

- Liquid milk intake can be reduced by reducing the volume per feed and/or the number of feeds a day
- On ad-libitum milk systems the teats/nipples can be removed for part of the day to reduce intake
- Reducing concentration (dilution) of milk feed is not recommended.

Water
Clean, fresh, ad-lib water must be available daily to encourage rumen development.
Free choice water encourages calf starter intake and increases daily gain.

Calf starter
The desire of the calf to eat dry starter feed is determined by availability, quality and encouragement (in very young calves)
A high quality dry starter feed should be provided fresh, daily in clean containers.

- Offer starter feed on an ad-lib basis from 3-5 days of age
- Encourage calf to eat as much as possible
- Meet calf nutrient requirements as milk intake is reduced
- Reduce incidence of bloat from gorge feeding
- Know how much calf starter is consumed.
- Weigh feed and mark a container with target weights up to 1kg. Check weigh regularly.


Check weigh measuring jug

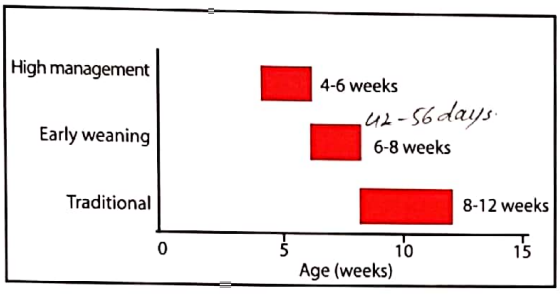
Fact
Dry starter feed intake is an essential prerequisite for final weaning

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Weaning
Application

When to wean?
The weaning period in calf rearing usually takes place between 5 and 12 weeks of age.
Weaning transition period usually takes place over a 4 week period (2 weeks before, 2 weeks after).



The decision?
The decision to wean is based on the level of dry starter feed intake/ rumen development not age or live-weight.

A calf is ready to wean when:
- it is has sufficient rumen development
- it is consuming enough dry starter feed
- it is healthy and growing well
- it is not stressed

Do not wean calf during periods of additional stress, e.g. respiratory illness, bacterial infection, dehorning, exceptionally hot or cold weather etc.

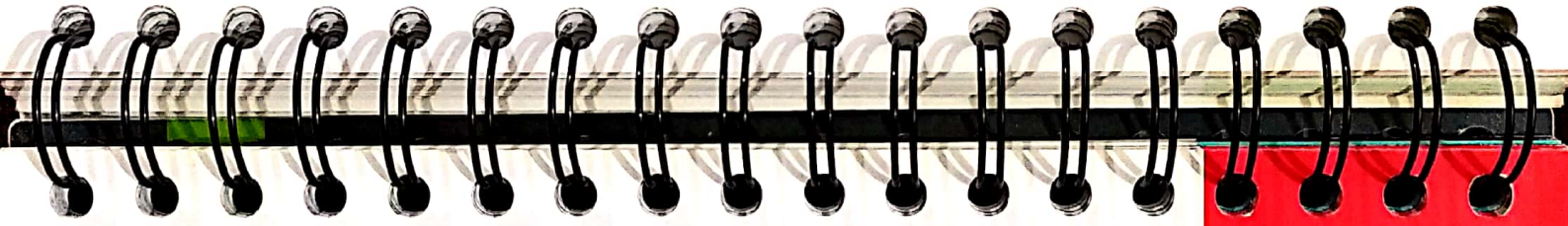
Target

HOLSTEIN CALVES
Minimum 1.0kg (2lbs) calf starter feed for at least 3 consecutive days

Target

JERSEY CALVES
Minimum 450g (1lb) calf starter feed for at least 3 consecutive days

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Weaning
Application

Management

How to wean?
Calves must be provided easy access to fresh calf starter, from the beginning of the rearing period, to encourage intake.
Concentrate consumption in the period immediately before weaning can be increased by restricting the availability of milk replacer.
The ability of the calf to eat dry feed (starter) at weaning is in direct proportion to the volume of liquid feed being offered .
Nutritional intake must be maintained, during the weaning process or growth will be affected.

There are two basic methods of weaning:
Abrupt weaning:
- Milk feeding is stopped abruptly and calf relies on starter feed only.

Graduated weaning (the preferred method):
- Daily milk allowance is gradually reduced over 7-14 days by reducing volume per feed and/or the number of feeds a day.

For automatic feeding systems, weaning can be encouraged by limiting daily access to nipples (12 hours access per day for 1 week and 6 hours per day access, the week before weaning.

Example graduated weaning program
(starting 2 weeks before weaning)

- week 5- 3 litres milk twice a day
- week 6- 2 litres milk twice a day
- week 7- 2 litres milk once a day

What to do after weaning?
Minimize stress/change for about 7-14 days after weaning, i.e. do not rehouse, group, change feed or personnel etc.
Provide the same high quality starter feed in clean containers on ad-libitum basis for 7 days.
Provide high quality forage (e.g. hay) to encourage growth of rumen muscular layer and health of the rumen epithelium.
Group calves in small groups according to body weight/size (maximum 4-6 per group, for first 2 months).
Make any changes in feed and routine gradual.
Ensure calf environment is clean, well-bedded and has adequate ventilation to reduce risk of exposure to pathogens.

Goal
- minimal growth check
- health evaluation
- optimal economics

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Weaning
Evaluation

Practical assessment of weaning methods

Weaning method	Typical suitability	Pros	Cons
Abrupt weaning	Calves weaned at 8-12 weeks of age Calves receiving small volumes of milk daily. Once a day feeding, low growth rates	Less management input	More susceptible to growth checks if rumen not well developed (weaning stall-out) Higher overall milk input Less economic
Graduated weaning	Calves weaned at 4-8weeks of age Ad lib feeding systems Feed programs where large volumes of milk are fed for high growth rates	Less susceptible to growth checks Less stress on calf More adaptable to calf needs Increased efficiency of gain Higher economics	Higher management input

Weaning age and production traits

Weaning 'transition' is a period of stress for the calf. Stress lowers calf immunity and increases susceptibility to disease.
Weaning before four weeks of age presents more risks and usually leads to a higher mortality rate.
Weaning later than eight weeks of age is costly in feed and labour costs.
Research has shown that weaning age does not affect comparable age body weight, hip/ wither height post weaning.
Research has shown that weaning age does not appear to affect age at calving or first lactation milk production.

Post weaning stall -out

Growth rate can stall or decline for 1 to 3 weeks post weaning.
This can occur at any age as a result of calves having an insufficiently developed rumen and/or insufficient nutrient intake to meet nutrient demands.
Under developed calves are unable to digest and utilise sufficient dry starter feed to meet growth requirements.
Too much forage can limit starter concentrate nutrient intake and reduce rumen development and growth rates.
Environment conditions will affect calf feed intake and so nutrient supply to meet growth requirements.

Check list

- ✓ Adjust milk intake levels to encourage dry starter feed intake
- ✓ Know the weight of calf starter fed
- ✓ At weaning calf must consume a minimum of 1kg (2lbs) high quality calf starter for 3 consecutive days
- ✓ Minimize stress during weaning period and immediately after
- ✓ Only wean healthy calves that are eating and growing strongly

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Growth Targets
Explanation

Definition

Production goals of the young calf to meet lifetime objectives.

What is it?

Growth is usually described in terms of body weight and daily live weight gain (DLWG) measured in kg/day or grams/day.
Body weight gain alone should not be the sole measure for developmental traits and targets of calves.

Other important parameters to consider are:

Parameter	Explanation
Rumen development and weaning goals	Transition to functioning ruminant
Frame growth	Skeletal and muscle development
Production	Breeding weight and age Body growth composition Mammary gland development
Efficiency of feed utilisation/ FCR	Kg feed dry matter required per kg liveweight gain
Strong immunity	Optimum health

Why is it important?

- To set goals for calf rearing to meet subsequent production goals
- To plan a feeding strategy from birth for every stage of the calf rearing program
- To achieve a high standard of performance as economically as possible
- To maximise the use of the high efficiency of gain from feed of the pre ruminant animal



Goal

Optimum growth and development over time to enable expression of full genetic potential

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Growth Targets
Application

What can be used to monitor growth and development?

- Live weight measurements over time to provide daily live weight gain
- Wither height, to measure skeletal development (frame)
- Body condition score for composition of growth (body tissue mass)
- Feed efficiency as an indication of how efficiently feed is utilised (amount of feed eaten per kg gain)

How to measure growth and development

Live weight is ideally measured using weigh scales.
Size can be measured using a girth/weigh tape, wither height or hip height/width.

Girth tape:
Measures heart girth and is correlated to indicate live-weight for large and small breed dairy cattle. Specialist calf weigh tapes are available for young calves

Wither (W) and hip height (H):
Can be correlated to live-weight but are less accurate than weigh scales. (See photo opposite and appendix for tables)

Hipometer:
Measures hip width and has been correlated to live weight for heifers. Accuracy depends on correct use and consistency of use. Results can vary dependant on the user.

Any form of measurement device must be calibrated regularly and/or checked for accuracy.

The weigh or girth tape requires the animal to be standing normally ideally with head forward and legs comfortably together.

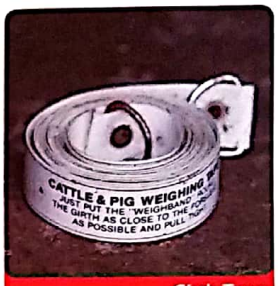


Top tips

Identify calves

Keep records

Measure and monitor growth & performance



Girth Tape

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Growth Targets
Application

Management

What influences growth targets?

Growth targets will be 'defined' by the breed of cattle, feeding and management systems available.
Growth targets will be 'achieved' dependant on the type and amount of liquid feed, management capabilities and health status of the rearing unit.

High Influence

Feeding management Ad lib feeding systems and high feeding rate programs (accelerated feeding) will have higher growth rates than restricted feeding systems from limited intake.
Health management Poor health and immuno-compromised calf will have reduced growth rate potential.

Others

Breed Birth weight influences growth rate from feeding rate. Energy requirements increase for larger calves.
Genetics High genetic merit animals have higher growth and production potential
Sex Uncastrated bulls have 12% advantage over heifers

Environment temperature Extreme temperatures can reduce growth rate. Maintenance energy requirements increase in cold environment conditions.

Target daily liveweight gains (g/d) for holstein calves

Feeding method	0-5 weeks	0-12 weeks
Restrict fed – once a day	400	700
Restrict fed- twice a day	500	700
Cold Ad-lib	700	800
Machine ad-lib	800	800
Accelerated/ Enhanced	800+	900+

Target

% of mature body weight

Puberty – 40-50%
Service/Breeding- 50-60%
Calving 24months -85%

Typical heifer targets for 2 year calving

	Birth weight (kg)	Weight, 3 month (kg)	Calving weight (kg)	Weight mature (kg)	Daily gain 0-3 mth (kg/day)
Holstein	45	100	580-615	650-725	0.6-0.8
Friesian	40-45	93	515	600	0.6
Jersey	26	75	385	425-475	0.5
Guernsey	35-40	80-100	466	525-580	0.55
Ayrshire	40	95	485	600	0.6

See Appendix for more information

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Growth Targets
Evaluation

Trouble shooting

Production parameter	Considerations
Poor pre-weaning average daily gain	Quality of liquid feed Feeding amount received is correct Milk temperature, concentration, mixing Health disorders Stress (cold, environmental, housing, etc)
High pre weaning morbidity or mortality	Colostrum management Hygiene management Growth rates (Levels of IGF-1, an important regulator of cells of the immune system, are correlated to growth rates- Drackley)
Delayed breeding age	The onset of puberty is largely a function of bodyweight Check growth targets are suitable and correct amount/type of feed is being provided Delayed 1st calving age increases herd costs and numbers (extra 2-3 heifers/100cows /month delay)
Reduced milk production ability	Inadequate size at first calving may limit milk production and conception rate during first lactation Too high a growth rate in the period from 3-15 months can have a detrimental effect on mammary gland development Feeding for higher gains in the early calf phase could offset excessive gains in the heifer rearing stage, reducing the risk for impaired mammary development

Check list

- ✓ Plan feeding, management and health policies for growth targets
- ✓ Implement the plans
- ✓ Measure and monitor growth and condition regularly and consistently
- ✓ Adjust plans to maintain growth targets
- ✓ Identify calves and maintain records

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Housing – Physical
Explanation

Definition
A place of shelter in which calves are reared

What type of housing?
Individual - Pens, Hutches
- Easy to manage
- Reduced risk of transfer of disease
- Can be easily located in suitable position
- Flexibility

Group - Barn or super-hutch
- Calves are reared in pens of 10-12 calves
- Maximum of 20 calves per house per room
- Age groups should not be co-mingled
- Suitable for computer controlled milk feeders that are labour saving and can improve feeding consistency
- Encourages early social interactions, important in the development of normal social responses later in life
- Provides more space, allowing for more vigorous activity and play.

Feed storage
- Storage of at least one month's feed usage
- Area for feed preparation
- Minimizes need to be in calf housing area.

Why is it important?
Calf housing provides
- A suitable environment for the calf and stockperson from birth up to 12 weeks of age
- A calf rearing system for high performance and health status
- Space away from adult cows, sick or recently weaned calves
- To provide some control system for ventilation with changes in temperature and weather.



Target
Provide the basic needs of the calf and be adaptable to environmental change

Target
Fresh, dry air is essential for good health and growth

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Housing – Physical
Application

Management

General calf recommendations and suggested minimums

Space - for comfort and well-being (Pen width must be greater than the calf wither height)

Suggested minimum pen dimensions:

Individual pens	1.7 x 1.2m per calf (1.5-2m²)
Hutches	1.2 x 2.4m per calf (2.0-2.9m²)
Group	1.5-2 m² per calf
Air capacity	minimum 6 to 7 m³ (212 cu.ft) per calf

Lighting - cattle are daytime creatures

Natural light – 10% of roof as translucent sheeting
Artificial – 100-200 lux at calf level to aid observation

Drainage - counteracts liquid output and leads it to final drains

Typical flooring slopes:
Pen floor, at least 1 in 20 gradient back to front.
Feed preparation area, at least 1in 40 gradient to drain.

Heating - may be required for sick calves. e.g. Quartz linear lamp

Feed space- to allow calf to feed easily
Locate away from resting area, easy to clean and deliver feed.
For starter use a shallow bowl so they can lick bottom.

Water - separate vessel to milk feed or automatic drinker

Individual- one pail/drinker per pen
Group- one water vessel per 10-12 calves

Location - easy access, reduce weather/environment impact

Direction/shelter opening from prevailing weather conditions e.g. Hutch opening face south.
Observe position of openings and use shade cloth or panels if required.
Sunlight encourages drying of bedding and warmth in winter.

Hygiene - effective cleaning and disinfection

Always maintain an all in all out system with time to clean, disinfect and rest housing between calves.





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Housing – Physical
Application

Management

Calf hutches

Materials
Hutches are usually made of plastic or wood.
Opaque plastic reduces sunlight penetration and so heat and humidity build up.
They must be easy to move and clean between calves.

How long for
Usually up to 8 weeks of age and then transferred to group facility, barn or super hutch.

Drainage
Site hutch on a prepared bed of 100cm of gravel to ensure adequate drainage.

Hygiene
Clean and disinfect between calves.
Turning hutch over exposes it to sunlight (u.v.) that provides an additional disinfectant procedure.

Group housing

Materials
Cold or warm barn with pens.
Layout of pens depends on overall space available and accessibility

How long for
Up to 5 months of age.

Drainage
Floor usually concreted and sloped as detailed previously.

Lying area
A well bedded and airy area which can easily be observed.

Open yard
For feeding and day activity a windbreak can be used for wintertime.

Hygiene
Always maintain an all in,all out system with time to clean, disinfect and rest housing between calves.





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Housing – Physical
Evaluation

Management

Trouble shooting
Due to the large variation in housing available, trouble shooting must be on a practical basis.

Problem	Effect on calf	Action
Space too small	Inadequate, comfort, well-being of calf. This can affect nutrient utilization and performance	Ensure individual pen allows for growth of calf breed/genotype reared Reduce stocking rate in group pens
Poor hygiene controls	Increases risk of pathogens and disease transmission	Practise an all-in all-out system. Maintain a diligent cleaning protocol of buildings, equipment and personnel
Poor ventilation	Excessive moisture, draughty, exposure to ammonia fumes and aerolized pathogens, increases stress and risk of pneumonia	Ensure ventilation is adequate for calf numbers. Monitor and maintain with the environment
Poor health	Immune response compromised due to low Ig status and/or poor nutritional intake. Calf is unable to control pathogen challenges	Ensure good colostrum management Observe calf feed intake and condition daily, Monitor growth Minimize stress from effects of temperature and humidity Maintain consistency



Check list
- ✓ Adequate space per calf
- ✓ Dry, draught free, well ventilated
- ✓ Consistency of internal environment
- ✓ Design that suits climate and farm
- ✓ Labour efficient housing
- ✓ Maintain hygiene procedure for buildings, equipment and personell

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Management

Housing – Environment
Explanation

Definition
The conditions immediately surrounding the calf

What is it?
The environment surrounding the calf can have a major influence on its nutritional requirements and health. Environment conditions surrounding the calf (and thus 'comfort') are affected by:

1. Air movement/ventilation
2. Air quality
3. Humidity
4. Temperature
5. Bedding



Why is it important?
Low 'comfort' increases energy demand and stress resulting in reduced performance and immune response.
Low comfort increases animal contact with manure and other contributors to pathogen exposure.
Poor environment increases the risk of infection, disease transmission and mortality.
The presence of shedding animals (FPT calves, stressed calves, chronically sick calves or poor doers) requires particular attention. Disease, such as pneumonia, may be encouraged from ventilation limitations that result in excessive moisture levels, exposure to ammonia fumes and aerolized pathogens.

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Housing – Environment
Application

Management

Air movement/ventilation

- A method of circulation and replacement of stale or noxious air with fresh air by natural or mechanical means. (Noxious gases include ammonia, carbon dioxide and methane)
- A method of removing moisture produced by the calf from the housing space
- It helps transfer heat away from the body, cooling the animal in hot environments but may lower the environmental temperature below the LCT in cold environments
- It should be able to be controlled to avoid inadequate or excessive air movement
- Cubic air capacity, height and space, ensures airflow above calf height reducing risk of drafts
- Adequate cubic air capacity reduces the danger of disease cross infection by diluting the concentration of disease organisms
- Enclosed housing is much more involved in the control of the air environment through natural ventilation and mechanical fans.

Natural ventilation - provided by wind and barriers.
a. Hutches- Weather shielded vents enable air circulation. Air movement can be encouraged by opening them as much as possible. Propping up the back of the hutch, about 6 to 8 inches allows more air movement inside in hot weather.

b. Enclosed housing

Housing design	Min recommendations
Inlet area for fresh air at eaves Outlet area for stale air at ridge Height between inlet and outlet	0.045m^2 (0.5 sq.ft) per calf 0.04m^2 (0.4 sq.ft) per calf 1.5-2m (5-8 ft)
Ridge per 10ft building width	5cm (2")
Eaves per 10ft building width	2.5cm (1")
Ceiling slope	Minimum 1:4
Walls	½ sidewalls

Mechanical air movement - when natural ventilation is inadequate.

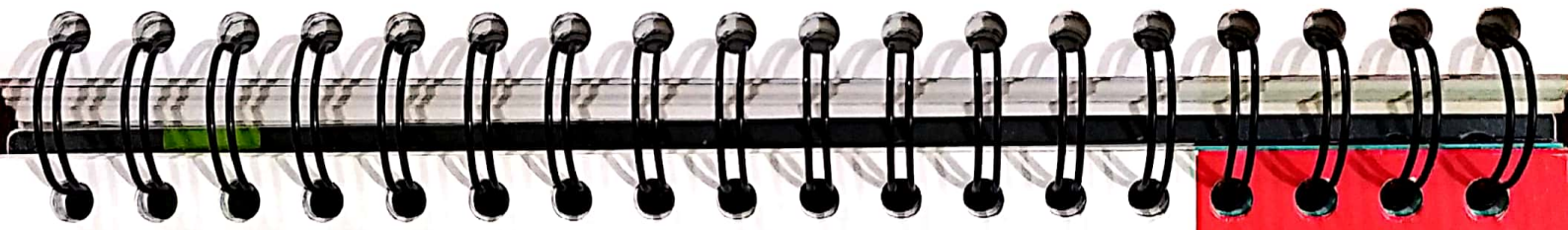
Recommended levels per calf up to 2 months of age.

Ventilation	Cubic feet of air per minute (cfm)
Mechanical air movement from fans	20-62 (35-105 m^3 per hour)
Mechanical air exchange rate close to calf	15 cold weather 50 mild weather 100 hot weather

Top tip

It is too draughty if you can feel a draught on the back of your hand at calf level

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Housing – Environment
Application

Management

Humidity

- A measure of the amount of water vapour (moisture) in the atmosphere, usually expressed as either absolute humidity or relative humidity
- Humidity surrounding the calf is due to weather conditions and calf respiration
- Each calf respires approximately one liter of water vapour into a room environment every day
- Evaporation of body heat from the calf occurs via water loss from sweat and breath (panting)
- Calf response to humidity is related to air temperature

Environmental temperature

- Environmental temperature consists of 'Air Temperature' (the temperature of the air around the calf) and 'Effective Ambient Temperature. EAT (the actual temperature felt by the calf)
- Calf housing generally does not need to provide additional heating beyond the calf's own body mechanisms
- Housing must aim to maintain the thermo-neutral zone of between 10°C to 26°C. (See environmental extremes for more details)
- In very cold environments, calves in hutches can be provided with blankets
- Housing for very young calves is more critical as the lower critical temperature (LCT) is higher. For example
  LCT of 1 day old calf 13.4°C
  LCT of 10 day old calf 10.8°C

Bedding

- It must keep calves clean and dry to minimize soiling and wet hair coats
- Type may be dependant on environment/weather/ availability/ cost etc.
- Long wheat straw is an excellent bedding and acts as insulation
- Contaminated bedding must be removed from the housing facility
- Pneumonia or diarrhoea pathogens from bedding can be aerosolized

The 'kneel test' provides an easy assessment of bedding:
Soiled knees = insufficient bedding, risk of bacterial challenge
Wet knees = insufficient bedding, taking heat from calf

How to manage the housing environment

- Monitor, regularly to maintain consistency
- Minimize changes/effects of temperature and humidity through well-ventilated housing
- Ensure each calf has sufficient cubic air capacity for air quality conditions
- Assess bedding daily and provide additional as required
- Relative humidity in calf facilities is ideally between 50 to 70%

Target

Minimum 3" (7.5cm) clean dry bedding between calf and clean floor



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Housing – Environment
Evaluation

Management

Effects of housing environment on the calf

Parameter	Effect on housing	Effect on calf
Inadequate ventilation	Excessive moisture levels, ammonia fumes, aerolized pathogens	Encourages disease such as pneumonia
High Humidity	Increases moisture levels Encourages pathogen multiplication and survival	Reduces the rate of evaporation Increases heat stress susceptibility Increases energy demand Increases susceptibility to respiratory problems
Low environmental temperature	EAT drops below LCT	Increases energy demand to maintain body temperature Reduces growth and immune response unless extra feed is supplied
Inadequate bedding	Insufficient heat production Soiled bed close to calf Wet bedding	Increases energy demand to maintain body temperature Increases exposure to pathogen and risk of disease Increases heat loss and provides moisture for bacterial growth

Check list

- ✓ Evaluate housing for good air movement
- ✓ Ensure good air quality
- ✓ Ensure clean, dry, well–bedded area for each animal
- ✓ Position hutches appropriately and monitor inside air temperature
- ✓ Minimize stress situations
- ✓ Check the weather forecast and be aware of seasonal changes

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Management

Environmental Extremes
Explanation

Definition
Environment conditions that cause the ambient temperature around the calf to exceed the thermo-neutral zone and so affect the calf's ability to function effectively.

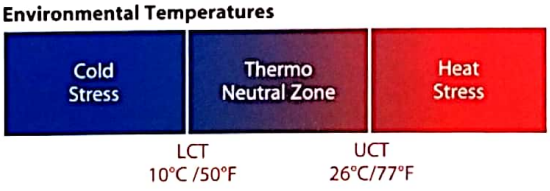
What are they?
Environmental temperature consists of:
- **Air temperature** (temperature of the air around the calf)
- **Effective ambient temperature, EAT** (actual temperature felt by the calf)

The EAT may differ from air temperature due to other factors affecting the environment around the calf.

The **Thermo-neutral zone** is the environmental temperature range in which a calf maintains its body temperature using no additional energy (heat production balances heat loss).

The ability of the young calf to overcome environment extremes can be affected by: age, size of calf, amount of feed intake, amount of subcutaneous fat, genetics and length and thickness of hair coat. E.g. Some cattle breeds have shown a lower cold tolerance indicated by lower thermogenically active brown adipose tissue at birth (do not utilize brown fat as effectively as an energy source). E.g. A Brahman calf is less cold tolerant than an Aberdeen Angus.

Environmental Temperatures



Calves have a thermo-neutral zone considered to be 10°C to 26°C. These are also described as the lower critical temperature (LCT) and upper critical temperature (UCT), respectively. The graphic shows guidelines for one month old calves as LCT declines with age.

Why is it important?
- Calves have a much larger surface area per unit body weight than cows, allowing more rapid heat loss and so are less tolerant to cold
- Extremes in both heat and cold will impact the calves' efforts to maintain a constant level of body heat
- Higher maintenance requirements, reduces growth performance and has a negative effect on efficiency and health
- Environment extremes increase susceptibility to stress of the calf that can affect calf health and performance
- Environment extremes may affect digestibility of feed

Fact
Small and young calves (0-3 weeks age) are most vulnerable to environment extremes



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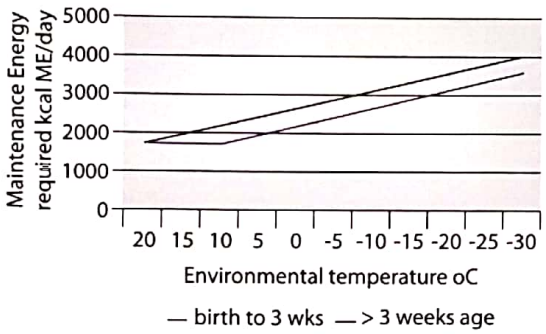
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Environmental Extremes
Application

Management

What are environment effects?
Environment conditions surrounding the calf are affected by temperature, air movement and air moisture (humidity)

Environmental temperature
Extremes in both heat and cold, outside the thermo-neutral zone, result in a higher 'work' rate and energy demand to maintain a constant internal (core body) temperature. This increases the maintenance energy requirement of the calf. Extra energy must be provided from the diet as a newborn calf has minimal body fat and limited energy reserves.
E.g. a day old calf at LCT of 13.4°C has energy reserves for approximately only 18 hours, Okamoto, 1986.



High air temperature and sun (radiant) heat increases skin temperature enough to cause discomfort (EAT can increase by as much as 3-5°C in sunlight). Black coats absorb more radiant heat than mostly white coats. This increases body temperature. Rumination also increases body temperature.

Evaporation of body heat from the calf occurs via water loss from sweat and breath (panting). High temperatures reduce appetite and require increased water intake. These all have a negative effect on performance and health.

Air movement
Draughts and high ventilation rates increase cooling of calf and increases susceptibility to cold stress.
Effective ventilation of housing can increase transfer of heat away from the body (evaporation) and help to cool the calf in hot conditions.

Humidity
Moisture on hair coat reduces its insulation value and so EAT around the calf. Housing conditions, such as bedding condition, can influence relative humidity around the calf
High humidity levels reduce the rate of evaporation and increase heat stress susceptibility.
High humidity encourages pathogen survival, increasing risk of disease, such as pneumonia. It is more difficult to overcome humidity than temperature.
Target temperature- humidity index is 72

Top tip
Increase observation during periods of stress for signs of sickness and reduced performance

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Environmental Extremes
Application
Management

When are the critical periods?
Cold stress periods
These generally occur during winter season when environmental temperatures are **below 4°C for a prolonged period**. The impact of air temperature on the calf will vary with region/country dependant on other surrounding conditions and suitability of housing.

Heat stress periods
These generally occur during the summer season and are more intense/ longer dependant on geographical location. Other prevailing environment conditions, such as humidity and wind, can have an impact on the EAT. With increased presence of global warming, awareness of the effects of heat stress and measures to reduce its effect on the calf will have to be practiced.


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Target
Maintain feed intake to offset environmental stress

Minimize economic loss

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Environmental Extremes
Application

Practical applications

	For periods of cold stress	For periods of heat stress
Housing	Ensure the calf has access to dry, well-bedded area free from drafts but with good air quality. Housing and bedding provide insulation to offset low air temp. A clean, dry coat is better insulation than a matted, wet coat. Bedding reduces heat loss to the floor.	Assess location to provide shade and to facilitate air movement. Provide supplemental shade to take off direct sunlight if required. Promote good air exchange by open doors, sidewalls on naturally ventilated structures. If required provide air movement with fans. Open hutches as much as possible (see housing environment).
Feed and energy requirements	Increase the daily amount of liquid feed being fed by 30-50% dependant on conditions (as an extra feed or add to regular feeding). # Milk replacer with fat <15%, change to higher fat milk replacer. Calf starter intake is not sufficient to maintain calf growth at low temperatures for calves 0-4 week's age. The higher energy concentration and digestibility of liquid feed provides a better choice. Ensure milk replacer is mixed to correct concentration.	Provide correct quantity of fresh liquid feed to meet any reduction in feed intake. Ensure milk replacer is mixed to correct concentration. Heat increases chance of fat rancidity and mould growth. Reduced starter intake may affect rumen development. Maintain high colostrum intake to offset potential weakened immune response.
Water	Ensure clean, fresh, water is available at all times. Starter feed intake may be stimulated by offering warm water 2-3 times daily.	Ensure clean, fresh, water is available at all times. Cool water (10-15°C) is preferable to help get rid of excess heat. Replenish and clean containers regularly, algae grow quicker in hot weather.
Immunity	Stress depresses immune system and so it is less responsive to disease challenges. Ig absorption has been shown to decrease during temperature extremes.	Ig absorption has been shown to decrease during temperature extremes. High temperatures have been associated with lower quantity and quality of colostrum, lower IgG and IgA concentrations.
Weather	Observe the weather forecast to be prepared for extreme environments and enable changes to be introduced gradually and so minimize stress and digestive upsets.	

Notes # e.g. To maintain same growth rate as 4.8litres of whole milk fed at 10°C for 45kg calf, requires additional 1.6litres at -10°C and 2.2litres at -20°C

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Management

Environmental Extremes
Evaluation

Cold stress

Calf observation	Evaluation	Explanation
Shivering	Calf is too cold	Calf will shiver to gain heat from muscular activity to try and increase its body temperature. Calf requires more energy from feed to maintain body temperature
Raised hair	Calf is cold	Calf tries to increase layer of insulation
Increased disease outbreak	Poor immune function, increased exposure to pathogens	Poor air quality can increase risk of respiratory disease. Calves with negative energy balance have reduced immune response
Increased feed intake (NB newborn can't do this on its own!)	Calf trying to overcome cold stress	Energy demand on calf increases as temperature falls to maintain normal body functions. Restrict fed calves will reduce growth rate unless more feed is made available. Dry matter digestibility reduces 0.21% per 1°C drop in temperature
Reduced growth/ condition	Feed energy intake is insufficient to meet increased energy requirements	Calf requires higher level of energy for maintenance and so less available for growth. Calf has limited fat reserves to use for heat production

Top tip

Pay attention during stress periods

Ensure sufficient feed for growth expectations

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Environmental Extremes
Evaluation

Heat stress

Calf observation	Evaluation	Explanation
Increase in water consumption	Inadequate water supply can lead to rapid dehydration, (loss of water and electrolytes such as sodium and potassium)	Water requirements increase exponentially as the temperature rises. E.g. Air temperature increase from 20 to 30°C increases water intake by 1 litre/day. As temperature approaches 32°C, water requirement increases dramatically. Calves pant and sweat to stay cool. Water is required to eliminate heat of metabolism and for efficient digestion of dry starter feed.
Behaviour- lethargic, seek shade, stand rather than lie down, panting, sweating	Elevated body temperature (rectal temperature>39.4°C (103°F)). Increased respiratory rate, >80 breaths per minute	Heat stress causes a calf's internal body temperature to reach dangerous levels. As rectal temperature rises to 42.2°C, mortality increases quickly. Humidity and heat reduces cooling mechanisms available to the calf and so body temperature rises.
Increase in disease outbreak. Reduced ability to fight off pathogens	Weakened immune system	Decreased immunoglobulins which circulate through the blood and ward off infections(Jim Spain, Professor of animal science at the University of Missouri) Calves may be at higher risk of failure of passive transfer
Reduced feed intake/ growth rate	Reduced appetite	Reduced feed intake, reduces energy available for growth as maintenance energy requirement has increased. Calf uses extra energy as it tries to cool. Diet digestibility can also be reduced. Energy concentration (via milk or milk replacer) must increase to balance demands and maintain growth.

Check list

- ✓ Observe the weather forecast to prepare for changes in environmental conditions
- ✓ Adjust housing, management and feed programs to offset environment effects
- ✓ Pay particular attention to newborn and sick calves in cold conditions, to improve chances of survival
- ✓ Increase observation

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Section 4

Calf Rearing Guide — Practical and easy to use

Health

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Hygiene
Explanation

Definition
The conditions and practises used to promote or preserve health.

What is it?
Hygiene practices are important in all areas of the calf environment, liquid feed preparation, handling, storage etc. Contamination and potential infection tends to be from faecal or aerosolized sources. These can include faeces, urine, saliva and secretions from the eyes, mouth and nose.

Important areas of hygiene awareness are:

Cow	Udder, soil, faeces, dirt etc
Housing	Ventilation, humidity, temperature, dampness, animal density, air quality
Bedding	Contact with calf of soiled bedding increases risk of bacterial challenge
Feeding equipment	Utensils, feeding vessels, pipelines, bulk milk tanks, etc
Feed	Collection, preparation, storage of colostrum, milk and dry feed
Water	For calf and washing must be of suitable quality and free of coliform organisms
Transport	Vehicles, holding pens, change of premises
Personnel hygiene	Hand washing etc

Why is it important?
Newborn and young calves are very susceptible to bacterial, viral and parasite challenges that can cause disease.
Their immune system and intestines are not fully developed for several months.

Good hygiene must be practised from the first few hours of life and throughout the calf rearing period
Bacterial colonization of the sterile newborn intestine occurs within a few hours of birth.



Fact

High standards of hygiene encourages a healthy gut

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Health

Hygiene
Application

Target

Minimize cross-contamination as much as possible

Fact

A warm, damp, humid environment will encourage bacterial growth

Hygiene control and management practises

Udder
Ensure cleanliness of animals and their housing. A well ventilated building helps to control environmental mastitis.
Prevent udders from becoming soiled, e.g. muddy gateways, drinking trough areas etc.
Ensure adequate teat preparation and post milking teat disinfection. Identify, treat, and record all clinical mastitis cases. Use milking equipment which minimises tissue damage and infection transfer.

Housing area
Allow adequate time between occupants of pens (minimum of 7 days). For continuous rearing, ideally give calf house at least 2 months rest in each year. Do not house calves near cows and other older animals. Remove all bedding and any organic material from stall walls. Clean with pressurized equipment and/or a hot 5% washing soda solution.
Disinfect area (generally at least 30 minutes required to act effectively before rinsing). Allow to dry before addition of fresh bedding. If possible seal and fumigate calf house for 24hours. Sunshine (UV light) is a good additional disinfectant; allow equipment to dry in the sun.
Provide a minimum of 3" dry bedding between calf and clean stall base.

Air
Minimize aerosolized organisms, noxious gases and other contaminants. Feed refusals can contain an abundant concentration of respiratory pathogens from oral and nasal secretions.
Manage ventilation, humidity, dampness, temperature, animal density, drafts (see housing page 84-91).
Be aware of seasonal variations and limitations.

Water
Clean and disinfect water vessels regularly
Conduct a water analysis, at least yearly, on all water sources and in particular well water sources.
Pay attention after heavy rainfall, excessive run-off and melting snow situations.

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Hygiene
Application

Feeding equipment and feed preparation areas:

Four step standard equipment cleaning and sanitising:
1 Rinse in lukewarm water (40°C, 105°F)
2 Wash with a detergent in hot water, (60-80°C, 140-180°F)
3 Rinse with clean water as 10% bleach solution (40-60°C, 105-140°F)
4 Allow to dry thoroughly

This should be followed after each feeding. Ensure self cleaning facility on automatic feeding machines is strictly maintained.
Pipes and teats can be a high source of contamination if not inspected and cleaned regularly.

General

Always wash hands with soap and warm water before and after handling calves, feed and feeding equipment.
Wear clean clothing and boots in calf area.

Feed

Store and feed colostrum and milk in clean, sanitized vessels at appropriate temperatures.
Remove all feed refusals daily from the housing area.
Store milk replacer and dry feed in cool, dry, sealed containers.

Storage limits

	Freezer (<0°F, -17°C)	Refrigerator (0-4°C,32-39°F)
Colostrum	12 months	7 days
Milk	6 months	7 days
Milk replacer	(see shelf life on bag- typically 6-12 months)	(see shelf life on bag- typically 6-12 months)
Dry Feed	(see shelf life on bag- typically 6-12 months)	(see shelf life on bag- typically 6-12 months)





Hand washing essential

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Hygiene
Evaluation

Biological quality

There are some standard methods to measure biological quality:

Standard plate count (SPC)
This relates to the keeping quality of products and counts the number of visible colony forming units in 1ml of sample incubated at 32°C for 48hrs.

Total bacterial count (TBC)
It counts the total number of colony forming bacteria per ml sample and is an indicator of proper sanitation and storage conditions.

Faecal coliform counts (FCC)
This indicates environmental contamination, poor sanitation techniques and/or mastitis infection.

High results indicate a problem in the cleaning and disinfection procedures of cows, equipment and environment, water supply and/or storage conditions.

Targets for newborn calves

Component	Total bacterial count (cfu/ml)	Faecal coliforms (cfu/ml)
Colostrum	< 50,000	<5,000
Milk or milk replacer	< 10,000	<10
Clean housing	< 5,000	<1,000
During occupancy	<2,000,000	<500,000

Check list

- ✓ Clean, healthy dam and clean calving area
- ✓ Provide comfortable and sanitized housing area for newborn
- ✓ Maintain strict sanitation practices for all personnel and feeding equipment
- ✓ Test bacterial and faecal coliform count
- ✓ Review and revise hygiene practises regularly

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Pathogens
Explanation

Definition
Any disease-producing agent, especially a virus, bacterium, other micro-organisms or fungus.

Why is it important?
Young calves are at a high risk from pathogens.
A strong immune system helps challenge low level pathogen exposure.
Many bacteria are normal inhabitants of the intestinal tract, overexposure or overgrowth can cause disease.
The intestines enable nutrients to be absorbed for maintenance and growth.
Pathogens can damage the intestinal villi (finger like projections that increase the surface area for absorption).
Damage to villi reduces the potential of the calf to absorb nutrients from food.
Diarrhoea and gut infections decrease fat digestion and lower absorption of fat-soluble vitamins A, D, E.

Infectious pathogens that commonly cause disease and scours in young calves

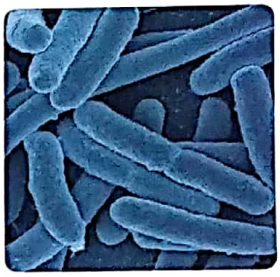
Bacteria	Virus	Protozoa
E.Coll (most common identified pathogen)	Rotavirus	Cryptosporidia
Salmonella spp	Coronavirus	Coccidia
Clostridium perfringens types B and C	Bovine Viral Diarrhea (BVD)	
Mycoplasma bovis	Bovine Leukosis Virus (BLV)	
Mycobacterium avium paratuberculosis,(Map)		
Staphlococcus spp		
Streptococcus spp		
Listeria monocytogenes		
Leptospira spp.		
Campylobacter spp.		
Pasteurella spp.		

Fact

Bacterial, viruses and protoza will be present during calf rearing

Fact

The immune system and intestines of the calf are not fully developed for several months



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Health

Pathogens
Application

How do pathogens enter the calf?
Pathogens can enter the calf via the respiratory tract, digestive tract, genital tract, wounds, mucous membranes (e.g. eye), navel, contaminated syringes, medication, insect bites.

How do pathogens survive?
Outside the calf
Bacteria require food, water and generally prefer non acidic conditions to thrive.
Bacteria numbers can double every 20 minutes, when provided with ideal conditions for growth. E.g. 20,000 cfu can increase to 160,000 in 1 hour.
Colostrum and milk (particularly discard/waste milk) at room temperature provide ideal conditions for bacterial growth.
Untreated waste milk has the potential for high numbers of pathogens that can rapidly grow.

Within the calf
Bacterial agents produce toxins that damage the villi, lining the small intestine. Surviving calves may be unthrifty due to intestinal damage.
Viruses attack the villi cells leading to malabsorption. The virus enters the cell and utilizes the cell's own material to reproduce. The cell ruptures and releases the new viruses to attack more cells. Viral infections make the calf more susceptible to secondary bacterial infections.

How to detect pathogens?
The pathogen causing disease can often be indicated from:
- Age occurrence of diarrhoea
- Typical symptoms/ signs
- Post-mortem

Pathogen type and numbers in the calf environment can be tested from:
- Feed (colostrum, liquid milk feed , water, dry feed)
- Faeces
- Blood
- Swabs from eyes, nose, throat

Samples may need to be refrigerated or frozen prior to arrival at a laboratory. Consult your veterinary surgeon.

Top tip!

Reduce the pathogen load and increase calf immunity to improve calf survival and performance







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Pathogens
Application

How are pathogens transmitted?

Pathogens can be transmitted via faeces; urine; saliva; secretions from the eyes, mouth and nose; air supply; feed and in utero.
Typical calf pathogens and their potential routes for transmission.

Organism \ Transmission route	Faecal	Airbourne	Milk[1]	Nasal/ Saliva	In Utero	Other
E.Coli	■	■	■			urine
Salmonella spp	■		■	■	■	
Clostridial spp.	■					soil
Mycobacterium avium sub spp	■		■		■	
Mycoplasma Bovis		■	■	■		
Infectious Mastitis[2]			■	■		
Pasteurella spp.		■	■	■		
Listeria monocytogenes			■			
Leptospira spp					■	urine
Campylobacter spp.			■			
Cryptosporidia	■					
Coccidia (Eimeria bovis, Eimeria zuernii)	■					
Rota & Corona Virus	■					
Bovine viral diarrhea (BVD)	■		■	■	■	
Bovine respiratory syncytial virus (BRSV)		■		■		
Parainfluenza Type 3 (PI3)		■		■		
Bovine Leukosis Virus (BLV)			■		■	

[1] Milk is defined as colostrum or non-pasteurized transition, whole or waste milk.

[2] Common causes are staphlococcus aureus, streptococcus dysgalactae, strep. uberis.

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Health

Pathogens
Evaluation

Summary of the most common bacterial disease causing agents

Bacterial	Typical age	Pathogen profile	Prevention strategies
E.coli Enterotoxemic (K99) (ETEC)	Within 3 days of life	Attach to intestinal wall and produce a toxin. Infection is rapid and often fatal. Electrolyte imbalance as calf tries to 'flush out' toxin. Dehydration is usually severe. Rapid disease with weakness, mild to severe diarrhoea, dehydration to death in less than 24 hours. Very common. Environmental. Highly infectious	Dry cow nutrition Vaccine Quality & timely colostrum Hygiene Milk additives
E.coli (Septicaemic)	Usually within the first week and up to 10-14 days	Invades the bloodstream and penetrates body tissues causing general infection. Rapid disease form often, with no evidence of diarrhoea. Calf rapidly depressed and weak. May die within 12 hours of symptoms.	Dry cow nutrition Quality & timely colostrum Hygiene
Salmonella spp. e.g. (*S.Typhimurium S.Dublin, S.Kentucky, S.Newport*)	5-14 days. symptoms usually 14-28 days age	Invades the mucosa of the small intestine causing inflammation and erosion of the lining. Calf has brown or green bloody scours. Bacteria may invade the bloodstream (septicaemia) and infect joints, brain, lungs and liver. Pneumonia can occur. High temperature and coma is common. Mortality rate tends to be high. Environmental. Highly infectious	Dry cow nutrition Isolation at birth Quality & timely colostrum Hygiene U.V. exposure Milk additives
Clostridium perfringens types B,C	5-10 days	Causes an intestinal necrosis and haemorrhage. Kills through a systemic toxin from the intestines, entertoxaemia. Sudden depression, weak, distended or abdominal pain. Abomastitis can lead to bloat. Sudden death syndrome is common. Wet, humid conditions favour this organism	Vaccine Quality & timely Colostrum Avoid overeating or poor Quality milk replacer Hygiene

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Pathogens
Evaluation

Summary of the most common bacterial disease causing agents continued

Bacterial	Typical age	Pathogen profile	Prevention strategies
Mycobacterium avium paratuberculosis MAP (Johne's)		Profuse and persistent diarrhoea, weight loss, poor condition, fever. Johne's disease does not usually affect young calves but calves can easily become infected during first 2 months of life.	Vaccine Quality & timely colostrum Hygiene
Mycoplasma Bovis	Birth onwards	Causes mycoplasma pneumonia, swollen joints and inner ear infections.	Vaccine Quality & timely colostrum Hygiene
Streptococci spp, Staphylcocci spp	4-30 days age	Can cause navel illness, joint ill	Quality & timely colostrum Hygiene
Leptospira spp. (5 strains)	6 weeks	Bacteria invade kidneys, liver, lungs and brain. High temperature; rapid, difficult breathing; depression; low suckle response; bloody urine (redwater); in coordination; death.	Vaccine Quality & timely colostrum Hygiene
Pasteurella spp. haemolytica A1, multocida, septica		Causes pneumonia and often secondary to viral infection. High temperature, nasal discharge, eye infection.	Dry cow/ calf vaccine Quality & timely colostrum Hygiene

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Health

Pathogens
Evaluation

Summary of the most common viral disease causing agents

Viral	Typical age	Pathogen profile	Prevention strategies
Rotavirus (more than one group and serotypes)	3-14 days (1-2 weeks)	Organisms are widespread in cattle and exposure of calves is common. Profuse, watery scours, near normal temperature, depression and dehydration. Virus is excreted in the faeces and remains stable and resistant to commonly used disinfectants. Not all calves develop diarrhea but damage occurs to intestinal lining.	Vaccine Milk additives Quality & timely colostrum Hygiene
Coronavirus	3-14 days	A pneumotropic virus that replicates in the intestines and the epithelium of the upper respiratory tract. Adult cows can shed viruses and peaks during winter months and at parturition. Similar to rotavirus (but more severe) causes damage to intestinal villi and watery diarrhoea (but not always) difficult to identify.	Vaccine Milk additives Quality & timely colostrum Hygiene
Bovine viral diarrhea (BVD)	4-10 weeks	Not common in very young calves. Calves exposed in utero may be persistently infected and source of cross infection. Calves show a high fever, accelerated breathing and severe diarrhea. Usually found in combination with other infectious agents. May have a factor in pneumonia after weaning	Vaccine Quality & timely colostrum Hygiene
Parainfluenza Type 3 (PI3)	2-4 months	Causes high temperature and respiratory distress, pneumonia.	Vaccine Quality & timely colostrum Hygiene
Bovine respiratory syncytial virus (BRSV)	Young calves	Severe form of viral pneumonia. Can be fatal after short illness. High temperature may blow rapidly. Often in winter months and bad weather	Vaccine Quality & timely colostrum Hygiene
Bovine leukosis virus (BLV)		Blood borne transmission is an important means of the spread of BLV from cow to cow. Not usually apparent <2yr old	Quality & timely colostrum Hygiene

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Pathogens
Evaluation

Summary of the most common protozoal disease causing agents

Protozoal agents	Typical age	Pathogen profile	Prevention strategies
Cryptosporidium parvum (most common)	5-35 days Commonly 14-21 days	Found on nearly every farm. It enters the animal through contaminated feed and water and can lay dormant in the manure and soil for up to one year. Usually causes mild to severe diarrhoea (white/yellow/green, watery and often bloody). It is not host specific. The eggs entering the intestine, release protozoa that multiply, attach to, enter and explode villi in the intestinal lining, This decreases digestion and absorption and results in diarrhoea, weight loss, dehydration, depression.	Quality & timely colostrum, Hygiene Pest control (rats and mice are carriers) Minimse stress
Giardia	2- 4 weeks	Many infections are unapparent unless calf is under stress (dietary/ environmental)	
Eimeria spp. (Coccidiosis)	3 weeks to 2 years 4-6 months most at risk	Not a major pathogen but incidence has been increasing. Usually poor doers with chronic diarrhoea. E.bovis and E.zuernii most common in cattle. Parasite damages intestinal cells and reduces ability to absorb nutrients and so affects future performance. Sub-clinical infection will not show diarrhoea but impairs calf resistance to other infections and reduces growth. Diarrhoea (watery with mucus and blood), loss of appetite, weight loss, weak, 'not doing well'. Dehydration and death can occur in 24 hours. Often associated with overcrowding.	Approved feed additives in milk replacer, water or starter. Prevention: decoquinate, lasalocid and monensin Treatment:amproliumA

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Disease
Explanation

Definition
Sub-clinical disease
An illness that does not show recognizable clinical signs but can reduce performance.

Clinical disease
This has recognizable physical signs and symptoms of sickness.

What is it?
Disease is a direct function of exposure to pathogenic agents in a quantity to overpower animal defence mechanisms.
The three most common symptoms of calf disease (responsible for >80% of calf deaths) are:

Diarrhoea (scours)
The result of non-infectious or infectious agents.

Pneumonia (inflammation of the lungs)
Usually occurs as a result of bacterial or viral infection.

Septicaemia
Often occurs as a result of a bacterial infection

Why is it important?
The young calf has a very delicate balance between health and disease.
Disease is a high cost to the producer, due to production and/ or animal loss.
Disease is a high cost to the producer, due to treatment and prevention costs.
The highest level of calf mortality is within the first 2-3 weeks of life.
Some infectious diseases are zoonoses, contagious across species, including man. E.g. salmonella, cryptosporidia, ringworm.
Other infectious diseases are notable as ecological problems, e.g Johnes disease.



Fact
Disease is most prevalent during the first month of life but can occur at any time.

Disease has a significant impact on growth and future productivity

Diarrhoea (scours) is the most common symptom of calf disease

Fact
Calf scours - indicated in >60% of calf deaths

Respiratory infections reported in 25% calf deaths

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Disease
Application

How to control disease?
1) Identify
a) Identify critical exposure points

Critical exposure points	Example sources
Calving	Adult cows and manure
Housing	Pens, bedding, ventilation (airborne pathogens), calf to calf contact (licking, nasal discharge,etc)
Colostrum/Milk	Poor hygiene (bacterial contamination), disease in the herd, inappropriate storage temperatures
Feed	Poor hygiene (bacterial contamination), feed refusals, poor storage
Water	Standing water, poor bacterial quality, poor hygiene of containers
Calf medications	Inappropriate storage/ application

b) Identify/monitor disease problems on farm

Calf records are an important tool in identifying disease and so effective prevention/treatment strategies.
Individual record sheets for each calf should be maintained for identification, health, morbidity (rate of incidence of a disease) and mortality.

Minimum suggested details for each calf are:
- I.D., sex, date of birth, time of birth
- Amount and timing and source of colostrum
- Blood protein level to recognize for failure of passive transfer of immunity (FPT)
- General observations
- Dates/signs of sickness and associated treatments, e.g. vaccinations, antibiotics, electrolytes etc
- Date of mortality and post mortem details if applicable.



Individual Calf I.D.

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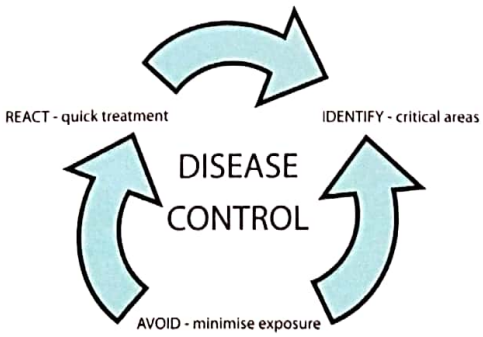
Health

Disease
Application

2) Avoid
Minimise Pathogen Exposure
- Sanitize calving pen, remove newborn calf immediately
- Provide good, sanitised housing for calf; maintain adequate clean bedding and ventilation
- Reduce risk of cross contamination E.g., wash teats and udder before collecting colostrum, isolate sick calves, do not share medications
- Maintain strict hygiene practices for feeding equipment and personnel
- Dilute or by-pass infection sources – e.g. consider colostrum replacer, milk replacer or pasteurisation if potential for positive test cows in pooled milk or colostrum, remove any feed refusals
- Sample, test and monitor colostrum, liquid feed, water etc for bacterial quality (total and faecal coliform counts)
- Avoid mixing calves of different ages

Increase Immune resistance/antibody protection
- Vaccinate dry cows and calves (reduces shedding, levels in environment and so risk of re-infection)
- Provide good colostrum management- volume, quality and timing of feeding
- Disinfect umbilical cord/navel
- Provide correct level of nutrition to meet calf requirements under exposed environmental conditions
- Supplement natural immunity, i.e. Vitamin A, D, E, selenium, zinc etc
- Minimize stress

3) React
- Observe calves regularly (minimum twice daily)
- Know signs of sickness
- Isolate sick calf
- Diagnose and treat quickly and effectively
- Where possible, maintain milk intake with small frequent feedings
- Consult with veterinarian



Fact

Calves with pneumonia during first three months of age are 2.5 times more likely to die after 90 days of age

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Disease
Evaluation

Calf morbidity and mortality are perennial problems

Which calves are most at risk?

1. Calves with inadequate transfer of colostral Ig's (FPT) (see colostrum).
2. Calves with prolonged exposure to adult cattle.
3. Calves exposed to high levels of pathogens.
4. Calves provided inadequate ventilation and housing conditions.
5. Calves provided inadequate nutrition (quantity, quality).
6. Calves under stress (e.g. poor environment, abrupt management changes).



Target

Target pre-weaning mortality <5%
Ideal 2-3%

Check list

- ✓ Identify critical disease exposure points
- ✓ Ensure strict hygiene conditions and cleanliness
- ✓ Increase immune resistance
- ✓ Maintain and monitor individual calf records
- ✓ Minimize stress
- ✓ Take extreme care when buying in calves

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Signs of sickness
Explanation

Definition
Indication/signals of disease or illness

What are they?
Typical signs of sickness include:

Physical symptoms:
- Droopy ears and cold to touch
- Abnormal temperature
- Abnormal dung
- Sunken eyes
- Dull coat
- Reduced appetite
- Poor growth
- Nasal discharge

Behavioural symptoms:
- Lethargy, weakness
- Reluctance to stand
- Depression
- Poor suckle response
- Reluctance to drink
- Standing apart from group
- Laboured, rapid, shallow breathing
- Grunting, whistling or coughing

Why is it important?

1. Early signals are often subtle and require skill, experience and effort to recognise them
2. Early diagnosis and treatment are important to reduce severity of disease and risk of transmission
3. Sickness and disease impairs normal physiological function
4. Sickness and disease reduces the calf's ability to grow

Top tip!

Early observation of sickness reduces disease risk

'Look at the ears!'

Fact

Prevention is better than cure

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Signs of sickness
Application

When to observe?
At least, twice daily observations by the same person for consistency. The calf is most susceptible to disease in the first few weeks of life.

What to observe?



1) Faeces/Dung
Check for quantity, consistency, colour and smell.
Healthy: Firm to soft, holds shape, not too dry; brown to light brown, normal odour, clean tail.
Sickness: An increase in the frequency and quantity of faeces, with a higher than normal water content.

Nutritional scours
– Pasty, soft, clay-like dung; yellow or white in colour
Infectious scours
- Increase number, loose to watery, bright yellow or green, strong odour, can be blood stained, mucousy.
(See page 118 for more details)



2) Posture of calf
Standing, lying, head position.
Healthy: Reactive to people and other calves
Ruminating calf – Lies with front legs tucked underneath its chest and sits on its haunches.
Sickness: Depressed, indifferent to others.
Head down, head pressing, twitching head extended upwards and backwards
Front legs stretched out may indicate pneumonia as calf tries to relieve pressure from chest pains. Thin calves with a potbelly. Tucked up abdomen. Swollen, hot joints



3) Eyes
Healthy: Prominent, bright, clear
Sickness: Dull, sunken, discharge

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Health

Signs of sickness
Application



4) Coat condition
Healthy: shiny, smooth
Sickness: dull, starring, damp



5) Ears
Healthy: pricked position
Sickness: one or both droopy ears and cold to touch



6) Nose
Healthy: Clean and damp
Sickness: discharge, frothy or mucous



7) Navel
Healthy: cord soft, thin and non painful
Sickness: swollen, hard, hot, painful (kicks, struggles)



8) Breathing
- number, depth, rhythm
Healthy: calm, even, respiratory rate
< 1 month age
-24-36 breaths per minute
> 1 month age – 15-30 breaths / minute
Sickness: Shallow, laboured, more rapid, uneven
Coughing, grunting, whistling

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Signs of sickness
Application



9) Rectal Temperature

Healthy:
Newborn Calf -
38.5-40.5 °C (101.3-104.9°F);
Calf Under 1 year -
38.5-39.3 °C (101.3-102.8°F)
Mature cattle -
37.8-38.9 °C (100-102°F)
Sickness:
Hypothermia < 37.8 °C (100 °F)
High temperature > 39.4°C (103°F)
Acute infection 40.5-41°C (105-106°F)



10) Eating habits

Healthy: strong suckle, ready for meals, finished meals,
Sickness: Unfinished meals, poor suckle response, drinks slower

11) Others

Healthy heart rate: < 1 month age: 120 beats per minute (100-130)
Under 1 year: 80-110 beats per minute
Adult cattle : 60-80 beats per minute
Sickness: Irregular, weak pulse

How to

Take calf temperature: insert rectal thermometer into rectum. Press it against the side of the rectum for one minute.

Respiration rate: Watch the rise and fall of the ribs for number, depth and rhythm.

Heart rate: Use a stethoscope on the rib cage just behind the point of elbow or use fingers on pulse points, jaw or under tail.

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Health

Signs of sickness
Evaluation

Common symptoms and management of calf sickness

Calf sickness	Typical symptoms	What happens?	How to manage
Scours/Diarrhoea: Non-infectious (nutritional)	Pasty, soft, white or yellow dung Calf loses appetite, weight, is generally weak, depressed and death can occur. Signs of dehydration and acidosis may occur.	Normal fluid exchange between the blood and intestine breaks down usually due to disruption of the digestive system Commonly caused by changes to the feeding program and/or stress	Avoid rapid diet changes Maintain regular feeding schedule Ensure correct milk temperature and mixing or rate Provide adequate intake of milk or milk replacer to meet energy needs Keep calf warm Match fluid intake to fluid losses by milk and electrolyte fluid therapy
Scours/Diarrhoea: Infectious	Profuse, watery faeces, bright yellow or white Blood-stained brown/ green faeces-suspect salmonella Blood stained with mucus-suspect coccidia Strong, foul odour Calf loses weight, is generally weak, fever	Caused by bacteria, viruses or protozoa infection. Transmission via faeces, urine, saliva, secretions from the eyes, mouth and nose, feed	Ensure good colostrum management Maintain strict hygiene practices Keep calf warm Match fluid intake to fluid losses by milk and electrolyte fluid therapy Observe regularly and carefully for secondary diseases Consult vet for antibiotic/ anti-inflammatory use

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Signs of sickness
Evaluation

Common symptoms and management of calf sickness

Calf sickness	Typical symptoms	What happens?	How to manage
Dehydration	Progressive dehydration (water loss %) % Signs Mild 5 few clinical signs, mild diarrhoea cool ear and leg extremities Depressed 6-8 skin tents for 2-6 seconds sunken eyes, depression dry mouth and nose Critical 8-10 skin tent > 6 seconds bodyweight loss depression increased pulse distinct sunken eyes dry mucous membranes fails to rise Coma 10-14 comatose cool extremities skin does not flatten poor pulse Death >14	Dehydration is a result of excessive body water loss (e.g. scours or hot, humid weather) or from water restriction (ice, dirty water, inadequate supply). It is usually progressive and reduces metabolic efficiency and feed intake. It also impairs the calf's ability to regulate body heat.	Match fluid intake to any fluid losses. E.g. 40kg calf, 5% dehydrated requires an extra 2 litres fluid per day. Replenish lost nutrients and salts promptly with fluid replacement therapy containing oral fluids and electrolytes (e.g. glucose, sodium, chloride, potassium, bicarbonate). The oral rehydration is in addition to the normal milk diet. Feed oral fluids 30 mins to 1 hour after milk feed. An oesophageal tube may be necessary if the calf is too weak. Intravenous fluids are required at >8% loss body water. Consult with your veterinarian

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Health

Signs of sickness
Evaluation

Common symptoms and management of calf sickness

Calf sickness	Typical symptoms	What happens?	How to manage
Bloat		Occurs in pre-ruminant animals as a result of excessive gas production by organisms (not necessarily pathogenic ones) in the reticulo-rumen or abomasum, shortly after feeding. Excess gas builds up and is unable to escape.	Ensure milk powder is mixed at correct rate and temperature and fed regularly. Check position of bucket or teat. Ensure correct nipple flow.
'Abomasal' bloat (right side distension)	Often within 1 hour of feeding and death can result within 6-48 hours from heart failure or asphyxiation. Calves are typically 5-10 days of age, (may occur up to 21 days age). Typically do not have diarrhoea but may show signs of anorexia.	Causes: Overfeeding, acidosis, abrupt diet changes, incorrect liquid feed. These tend to produce indigestion that slows gut movement, providing the sugars, proteins and lack of oxygen needed for rapid growth of Clostridia.	Can not be relieved by stomach tube and it is difficult for the animal to get rid of the gas spontaneously.
'Ruminal' bloat (left side distension)	Normal rumen contractions decrease and belching becomes impossible.	Causes: Faulty oesphageal groove function delivering milk into the rumen, abomasum overfill, excessive starter fermentation (fibre level too low, too much readily fermentable energy), legume forages, e.g alfalfa	Usually requires medical attention. Trapped gases can be released by passing a soft tube into the stomach. Do not restrict dry food intake and feed suitable product for calves.

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Signs of sickness
Evaluation

Common symptoms and management of calf sickness

Calf sickness	Typical symptoms	What happens?	How to manage
Acidosis	Depression, poor suckling reflex, dull, scaly coat, dehydration, alopecia (hair loss), poor body condition, clay-like faeces, abdominal distension, inappetance, inability to stand. Age occurrence typically 1-3 weeks (acute), 3-8 weeks (chronic). Can be rapid, severe and often fatal.	Occurs when there is a decrease in pH (acidity level) of the rumen or blood (ruminal or metabolic acidosis, respectively). Milk in the rumen (dysfunctional oesophageal groove reflex) is digested by bacteria. Lactic acid and volatile fatty acids are produced that reduce the pH and alter the bacterial population of the rumen. Can lead to lesions in the mucosa of the fore stomach, liver damage and ultimately death. Causes: weak sucking reflex, rapid ingestion of large volumes of milk, poor tube feeding, stress.	Seek Veterinarian advise Buffering agents (such as sodium bicarbonate) are usually successful.
Respiratory illness/ Pneumonia	Reduced feed intake; dry cough; rapid, difficult or irregular breathing; runny nose(thin and watery) changing to thick yellow mucus; discharge from eyes; fever (high rectal temperature), diarrheoa Post mortem – lesions on the lungs	An infection of the nasal passages, throat or lungs. Pneumonia is an infection of the lungs Typically Pasteurella spp and Mycoplasma spp, are implicated in the young calf Damage can be temporary or permanent dependant on severity.	Minimise stress and calf to calf contact. Ensure adequate colostrum. Maintain housing environment (humidity, ventilation, temperature changes etc). Immediate veterinary assistance is required. Early diagnosis and treatment minimises damage. Identify invading organism within 3-5 days. Screen/ vaccinate for BVD, PI3, Mycoplasma, Pasteurella etc.

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Health

Signs of sickness
Evaluation

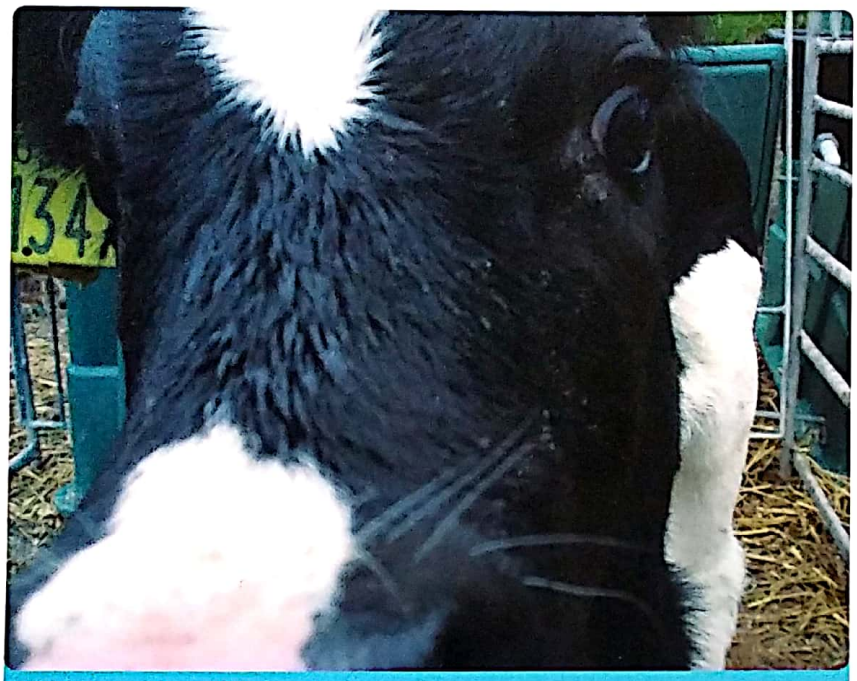
Common symptoms and management of calf sickness

Calf sickness	Typical symptoms	What happens?	How to manage
Navel ill	Navel swells and is painful, hot, hard with discharge Slight fever, listlessness	Environmental pathogens enter the calf's blood via the umbilical cord causing rapid systemic infection	Ensure clean calving area Apply 7% iodine solution to navel at birth and when placed in calf pen. Consult vet.
Septicaemia	Within 5 days of birth, calf is weak, depressed, reluctant to stand and suckles poorly. Calf may develop swollen joints, diarrhoea, pneumonia, meningitis, cloudy eyes and/or a large tender navel.	Occurs when disease-producing organisms or their toxins are in the blood Infection can occur from the blood of a sick dam, infected placenta, calf's umbilical stump, mouth, nose or wound.	Monitor dam health pre-calving Strict hygiene practices at calving
Lice	Loss of hair by rubbing. Common over shoulders and tail head- Coat arranged in lines on neck. Calf unthrifty	Lice eggs and lice apparent on hairs.	Dust calf with louse powder and repeat at 10 day intervals. Summer -sprays for fly control can control lice too.
Ringworm	Circular lesions covered with a grey, crusty scab Hair is brittle and breaks leaving bald patch and flaky skin. Most common on the neck and head but can occur all over the body	A fungus (Trichophyton verrucosum) grows on the skin and penetrates the hair follicle. Irritation causes rubbing and is a source of transmission to others if grouped. Spread by direct contact and indirectly via spores in the environment. Spores can survive for years.	Administer an oral antibiotic (Griseofulvin) for 7 days; dose related to weight. (Does not kill ringworm, prevents further growth). Or use a topical fungicide Consult veterinary surgeon Disinfect housing, feed areas, grooming equipment. Exposure to sunlight and good nutrition may also limit infection

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Signs of sickness
Evaluation



Maintain regular and thorough observation

Target

Pre weaning mortality <5%

Calf treatment rate <25%



Check list

- ✓ Observe calves at least twice daily
- ✓ Maintain individual calf records
- ✓ Be aware of repeated unusual behaviour
- ✓ Know signs of sickness and identify early
- ✓ Provide immediate and good supportive care
- ✓ Isolate sick calves
- ✓ Ensure calf is kept hydrated and warm
- ✓ Consult veterinary surgeon

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A

Abomasum - The fourth stomach of ruminating animals' equivalent to the only stomach present in single stomach animals. The abomasum secretes acids and enzymes to digest feed.

Absolute Humidity - The percentage of water vapour actually present in the air.

Acid Detergent Fibre (ADF) - A measure of the amount of highly indigestible plant material in a feed or forage. It includes cellulose, lignin and silica. The lower the value, the higher the digestibility or available energy.

Acidification - reducing the pH of a substance or solution; increasing the acidity.

Acidosis - Occurs when there is a decrease in pH (acidity level) of the rumen or blood (ruminal or metabolic acidosis, respectively). It can be rapid, severe and often fatal.

Acquired Immunity - Antibody production as a result of recovery from previous exposure to pathogenic microorganisms from the environment.

Active Immunity - artificially acquired immunity by use of a vaccine.

Acute - Said of a disease (or the phase of a disease) that is severe, intense and develops rapidly (opposite of chronic).

Ad-Libitum - Said of feeding, where animals have a free-choice access to feed (syn. Ad lib).

Apparent Efficency of Absorption - (AEA) said of Ig's into the blood; calculated value from the mass of Ig ingested, the plasma concentration following Ig absorption, and the plasma volume. It is highest immediately after birth and declines to nearly zero by 24 hours of age. Typical level is 35%.

Anaerobic (Bacteria) - Species of bacteria that live in the absence of oxygen, which is toxic to them.

Anorexia - Loss of appetite.

Antibody - Proteins, found in blood, colostrum other secretions, synthesized in response to an infectious agent (antigen) to exert a specific restrictive or destructive action on the antigen. (syn. Immunoglobulin).

Antigen - Any foreign substance, from the production environment or controlled vaccination, which in entering the body stimulates the formation of an antibody. These substances can be bacteria, virus, fungi and their toxic products or other materials, plant, foreign proteins etc.

Average Daily Gain - An indicator of growth calculated as the difference in body weight between two measurements divided by the number of days (typically grams/day or kg/day).

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B

Bacteria - Single celled organisms living either independently or in close association with other living organisms; often referred to as microbes or micro-organisms because of their microscopic size. Some bacteria are beneficial, but others cause infectious disease.

Bloat - Excess gas builds up that is unable to escape. In pre-ruminant animals it can occur in the reticulo-rumen or abomasum.

Butyric acid (Butyrate) - A fatty acid and product of rumen microbial digestion.

C

Calorie (cal) - A unit of measurement for energy.

Chronic - Said of a disease (or phase of a disease) that is prolonged, mild and characterized by the absence of any severity (opposite of acute).

Clinical disease - A disease which has recognizable physical signs and symptoms of sickness.

Closure time - Time after birth (usually expressed in hours) at which absorption of antibodies through the intestinal wall stops.

Coccidia - A parasitic protozoan that causes coccidiosis, invasion and damage of the intestine leading to diarrhoea.

Colostrum - Thick, creamy, yellow, sticky first secretion from the mammary gland collected at the first milking, within the first 24 hours, after calving. It contains antibodies, nutrients and growth factors.

Colostrum replacer - must contain adequate Ig's (> 75g IgG /dose) and other nutrients required by the newborn calf, i.e. energy, protein, vitamins, minerals.

Colostrum supplement - provides Ig's (<75g of IgG/dose) and other nutrients and is fed in conjunction with colostrum.

Complete feedingstuff - A mixture of feedingstuffs which by reason of their composition are sufficient for a daily ration.

Conduction - the transfer of heat between two parts of a stationary system, caused by a temperature difference between the parts.

Contagious - capable of transmission through contact with other individuals e.g. a causing organism.

Convection - the transfer of heat, through a liquid or gas, by the circulation or movement.

Critical temperature (lower) - Environmental temperature below which a calf has to use energy to maintain its body temperature.

Critical temperature (Upper) - Environmental temperature at which natural mechanisms, that act to help the animal lose heat, are insufficient to dissipate heat gain and so animal performance decreases.

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Appendix

Cryptosporidium - Parasitic protozoan that infests the intestine and causes diarrhea in young calves.

Curd - A thick mass of precipitated proteins that entraps fat, water and some minerals that is formed by acid or enzymatic coagulation of milk; curds are formed in the abomasum of young calves (syn. coagulum).

D

Daily ration - average total quantity of feedingstuff required by an animal of a given species, age category and production level to satisfy all of its needs.

Dermatitis - Inflammation of the skin.

Dehydration - Inadequate fluid intake and/or result of scours, usually progressive.

Diarrheoa - Abnormal frequency and liquidity of faeces (syn. scours).

Digestibility - the amount of feed nutrient that is digested and absorbed by the animal.

Disease - a direct function of exposure to pathogenic agents in a quantity to overpower defense mechanisms.

Dry Matter (DM) - The part of a feed which is not water. Usually expressed as a percent %.

Duodenum - The first part of the small intestine.

E

Eaves - The projecting overhang at the lower edge of a roof.

Emulsion - a mixture of two liquids that do not mix together well, such as oil and water, to which other ingredients are added to help hold the mixture together.

Enteric - Of or within the intestine.

Enteritis - Inflammation of the intestine.

Enterotoxemia - Disease caused by bacterial toxins produced in the intestine.

Enzyme - An organic compound that accelerates a biochemical reaction, without being used up in the process.

Epithelium - A single layer composed of closely arranged cells that form the covering of most internal surfaces and organs and the outer surface of an animal's body.

Escherichia coli (*E. Coli*) - A bacterial species that normally inhabits the intestine. Under certain conditions, it may become pathogenic, causing diarrhoea.

Erythrocyte - A red blood cell.

Evaporation - Conversion of a liquid into a gas (vapour).

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Evaporative Cooling - The loss of heat by evaporation at the surface of the skin or in the upper respiratory tract.

Exudate - A fluid that seeps from blood vessels into a body cavity or the tissues, often as a result of disease.

F

Feed (or feedstuff) - Any naturally occurring ingredient or material that has nutritional value in a ration to sustain animals.

Feed Additive - Any intentionally added ingredient that is not normally consumed as feed by itself, whether or not it has nutritional value, which affects the characteristics of feed, animal products or animal production.

Feed Efficiency (FCE) - The ratio of the number of feed units required for one unit of production (gain, milk etc) by an animal. (syn. feed conversion ratio, FCR)

Fermented Milk - Milk, left at room temperature (less than 21oC), in which the lactose is fermented into lactic acid. Fermented milk can be used to feed young calves.

Foreign Body -(See antigen).

G

Gastric - Related to the acid-secreting stomach (abomasum).

Growth - the increase in size of muscle, bones, internal organs and other parts of the body.

H

Homogeneous - Uniform in structure or composition throughout.

Hopper - Usually a funnel-shaped container in which contents are stored and pass by gravity into a receptacle below.

Host - An animal or plant from which a parasite obtains nutrition

Humidity - The amount of water vapour in the atmosphere, usually expressed as either absolute humidity or relative humidity.

I

Immune Response - the body's reaction to the presence of foreign substances, antigens. It is the synthesis of an antibody to neutralise or destroy an antigen.

Immune System - Tissues and organs (spleen, lymph nodes, etc.) involved in the defense against foreign bodies and responsible for the production of antibodies.

Immunity - The power to resist infectious diseases. It is inherited, acquired naturally or acquired artificially.

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Immunoglobulin (Ig) - also see antibody. There are several isotypes produced, classified according to their chemical structure and function. IgG, IgM and IgA seem to be the most important in the early survival of the young calf. (syn. antibody).

Immuno-stimulant - stimulant of the body defense mechanism .

Infection - Invasion of an animal by pathogenic microorganisms including bacteria, viruses, and internal parasites. This may or may not be followed by disease, depending on the immunity resistance to that agent, nourishment and stress status of the animal. Infection can occur by oral, aerosol and wounds.

Infectious Disease - A disease caused by a microorganism or other agent, such as a bacterium, fungus, protozoan or virus, which enters the body.

J

Joule (j) - A unit of measurement for energy.

K

Ketone Body - Intermediates in the body metabolism of carbohydrates and fat. The three ketone bodies are: acetone, aceto-acetic acid and ß-hydroxybutyrate.

L

Lactic acid - Acid produced by bacterial fermentation of lactose in milk.

Leukocyte - white blood cells, involved in the immune response.

Lysis - Destruction of microorganisms or cells by enzymes.

M

Macrophage - A class of immune cells (white blood cells) that scavenges, engulfs and destroys foreign bodies (bacteria, toxins, etc.).

Metabolism - The chemical processes by which cells produce the substances and energy needed to sustain life. In metabolism some substances are broken down to yield energy for vital processes while other substances, necessary for life, are synthesized.

Microflora - The community of bacteria and other organisms of the plant kingdom found in a microhabitat (e.g. bacteria found in the rumen or small intestine).

Milk Replacer - A dehydrated product that is mixed with water to form a solution with a composition similar to milk and used as a substitute for milk.

Milk - Secretion of the mammary gland throughout lactation.

Morbidity - The relative incidence of sickness or disease.

Mortality - The number of deaths in a given time or place.

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Mucus - Protective secretion of the mucus membranes; in the gut it lubricates the passage of food and protects the epithelial cells; in the nose and throat and lungs it can make it difficult for bacteria to penetrate the body through the epithelium.

Myopathy - Any disease of the striated muscles.

N

Neutral Detergent Fibre (NDF) - A measure of the amount of cell wall present in a feed determined by a laboratory procedure. It includes cellulose, hemicellulose and lignin.

Nutrients - Chemical substances found in feed materials that can be used, and are necessary, to give energy and build tissue. They provide for maintenance, growth, production and health of animals.

O

Oedema - Excessive accumulation of fluid in a tissue.

P

Palatability - taste, appearance, aroma, texture, temperature pleasing to the palate and in some cases to the olfactory nerves (auditory).

Panting - Rapid and shallow breathing that increases the evaporative cooling.

Papillae (rumen) - Small projections on the inner surface of the rumen and the reticulum wall that increase surface area of absorption of volatile fatty acids and other end-products of bacterial fermentation.

Parasite - An organism that grows, feeds, and is sheltered on or in a different organism (the host) while contributing nothing to the survival of its host.

Passive Immunity - Immunity provided by the transfer of antibodies from an immunized animal to an unprotected animal. E.g. dam (colostrum) to calf provides antibodies from the maternal immunity to natural local infections or pre- calving vaccinations.

Pasteurisation - Partial sterilization of food at a temperature and for a period of exposure that destroys harmful microorganisms without major changes in the chemistry of the food.

Pathogen - An agent that causes disease, especially microorganisms such as bacteria, viruses and fungi.

Pathogenic - Capable of causing disease.

Pepsin - A digestive enzyme found in gastric juice that catalyses the breakdown of protein. The optimal pH for coagulation is 5.3 and proteolysis 2.1.

pH - A measure of the acidity or alkalinity of a solution. Range from 0 (most acid) to 14 (most alkaline) with neutrality at pH 7.

Phagocyte - White blood cells that engulf and digest cells, microorganisms, and other foreign bodies in the bloodstream and other tissues.

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Appendix

Glossary

Plasma -The colourless fluid portion of blood in which blood cells (red, white and platelets) are suspended.

Pneumonia - Inflammation of the lungs caused primarily by viruses, bacteria, and irritants (physical and chemical agents).

Pre-ruminant - Stage of development of a calf at birth that refers to the way the calf digests its diet. At this stage, the rumen is undeveloped and the primary stomach is the abomasum.

Prophylactic - Acting to protect against or prevent a disease, e.g. vaccine

Protozoan - Primitive form of life in the animal kingdom, microscopic unicellular organisms.

Puberty - The stage of sexual maturation in which an animal become capable of sexual reproduction. In females, puberty is characterized by the beginning of an estrous cycle.

R

Radiant Heat - Heat transmitted by radiation (as from the sun).

Relative Humidity - The ratio of the amount of water vapour in the air at a specific temperature to the maximum amount of water that could be present in the air, expressed as a percentage. Indicates the degree of comfort or discomfort one feels from the humidity.

Rennet - The rennin-containing substance from the abomasum of the calf used to curdle milk

Rennin - A milk coagulating enzyme, found in the gastric juice of the abomasum of young ruminants and able to curdle milk. Used in making cheese and junkets. (Syn. chymosin)

Replacement Heifer - Heifer reared in order to maintain or increase herd size.

Ridge (of a roof) - The horizontal line formed by the junction of the two sloping planes of a roof.

Rumen - The first of the four stomachs of a ruminant, located on the left side of the body. It is lined by a mucous membrane with papillated epithelium. It contains populations of bacteria, protozoa and fungus that ferment partially-chewed food. The rumen is undeveloped at birth. A healthy, functional rumen can be developed by providing suitable dietary factors.

S

Salmonella - A rod-shaped bacteria, many serotypes of which are pathogenic and capable of causing salmonellosis.

Sanitise - To free from dirt, germs, etc., by cleaning or sterilizing. (syn. sanitize)

Septicaemia - Invasion of bacteria and their toxins into the bloodstream leading rapidly to death.

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Serum - The colourless fluid which separates from blood plasma, when the process of clotting takes place. It is, in effect, plasma which has lost its fibrinogen.

Specific Gravity - The ratio of the mass of a sample to the mass of water displaced by the same sample maintained at the same temperature. The specific gravity of water at 4oC is 1. SPORE: A small reproductive cell, usually unicellular, produced by plants and some bacteria, fungi, protozoa etc. They usually possess a thick wall enabling survival in unfavourable environmental conditions.

Subclinical - A disease or condition that does not show recognizable clinical signs but can reduce performance

Synergy - The interaction of two or more organisms (or agents) so that their combined effect is greater than the sum of their individual effects.

T

Teat - The small projection of a mammary gland through which milk passes. Also used to describe a device resembling a teat (syn: nipple)

Thermoneutral Zone - Range of environmental temperature within which an animal maintains its body temperature without expending extra energy.

Toxaemia - A condition produced by the presence of poisons (toxins) in the blood.

Transition Milk - The secretion from the mammary gland, from second milking onwards for the period 24-72 hours after calving. It has a composition in between that of the colostrum and whole milk.

U

Ulcer - An inflamed lesion on the skin or an internal mucous surface of the body that results in tissue death.

V

Vaccine - A preparation of a weakened or killed pathogen (or sub-unit components) that upon administration stimulates antibody production or cellular immunity against the pathogen but is incapable of causing severe infection. Used as a preventive inoculation to confer immunity against a specific disease,

Virus - Ultramicroscopic infectious agent that replicates itself only within cells of living hosts and cause disease. Consist of genetic material (DNA or RNA) surrounded by a protein coat.

Volatile Fatty Acids (VFA) - Used in reference to acetic, propionic and butyric acids found in rumen contents.

W

Whey - The watery part of milk that separates from curds, as in the process of digestion or cheese making.

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Waste Milk - Milk that cannot be sold. E.g. cows with mastitis or other bacterial disease that have had antibiotic treatment. (syn. discard milk)

Whole Milk - Unaltered milk collected from day 4 after calving until the end of a lactation (see also colostrum and transitional milk).

Wind Effect - Natural ventilation process by which warm air is displaced by large eaves or side wall openings.

Withers - The high point of an animal's back located at the base of the neck and between the shoulder blades.

Z

Zoonose - A disease communicable from animals to humans and vice versa under natural conditions.

www.atticacows.com

www.calfcare.ca

www.calfandheifer.org

www.calfnotes.com

www.das.psu.edu/dairy/nutrition/calves

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Heifer Growth Targets

Average weight and wither height

Age (mo)	Holstein* average weight(kg)	Holstein* wither height (cm)	Jersey average weight(kg)	Jersey wither height (cm)	Ayrshire average weight(kg)	Ayrshire wither height (cm)	Brown Swiss average weight(kg)	Brown Swiss wither height (cm)	Guernsey average weight(kg)	Guernsey wither height (cm)
1	62	84	46	76	65	79	68	83	60	80
2	86	86	61	79	87	83	93	88	82	85
3	106	91	75	83	109	88	119	93	99	90
4	129	97	91	88	131	93	145	96	126	94
5	154	99	116	91	153	95	170	101	148	99
6	191	104	132	94	174	100	195	105	182	103
7	212	109	151	98	196	103	220	109	189	105
8	240	112	170	100	217	105	245	111	213	108
9	270	114	184	103	238	108	269	115	239	113
10	296	117	199	103	259	110	293	118	250	113
11	323	119	211	105	280	113	317	120	281	115
12	345	122	232	108	300	115	340	123	284	118
13	367	124	243	110	320	118	363	125	318	118
14	398	127	258	111	340	118	386	126	341	120
15	422	130	274	113	360	120	407	128	365	123
16	448	130	283	114	378	121	428	130	381	125
17	465	132	297	115	397	123	449	130	405	128
18	484	132	316	115	416	123	469	133	424	128
19	493	132	323	116	434	124	488	133	435	129
20	531	135	343	118	451	125	506	135	445	130
21	540	137	351	119	468	125	523	135	473	130
22	560	137	368	120	485	128	540	135	482	133
23	580	137	372	121	502	128	556	138	500	133
24	590	140	383	123	517	128	570	138	501	134

Target breeding/ service for 2 year calving

Adapted from data from National Dairy Heifer Evaluation Project, USDA 1991-1992. *Recommendation for high genetic merit heifers. Growth targets should be adjusted to suit breed, genetic merit, calving and production targets.

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Appendix

Heifer Growth Targets

Average hip height and hip width for holstein heifers

Age (months)	Hip height (cm)	Hip width (cm)
2	96	19
3	99	22
4	103	24
5	107	27
6	110	29
7	113	31
8	116	33
9	118	35
10	121	36
11	123	38
12	126	40
13	128	42
14	130	43
15	131	44
16	133	46
17	134	47
18	135	48
19	136	50
20	137	50
21	138	51
22	138	52

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Unit Conversions

	Units metric	Conversion factor	Units imperial
Length	mm	x 0.04	ins
	cm	x 0.394	ins
	dm	x 3.94	ins
	m	x 1.094	yds
	dm(10m)	x 10.94	yds
	hm (100m)	x 109.4	yds
	km	x 0.6214	miles
Square measure	cm^2	x 0.155	sq.in
	m^2	x 1.196	sq.yds
	acre ($100m^2$)	x 119.6	sq.yds
	hectare	x 2.471	acres
Mass and Weight	g	x 0.0353	ozs
	kg	x 35.3	ozs
	kg	x 2.2046	lbs
	g	x 0.0422	cups
	metric tons	x 1.102	short tons
	metric tons	x 0.984	long ton
	mg/kg	x 1.0	ppm
	iu/kg	x 0.454	iu/lb

	Units metric	Conversion factor	Units imperial
Volume	ml	x 0.03381	fl oz
	litre (l)	x 33.81	floz
	ml	x 0.002	pint (UK)
	cl (10ml)	x 0.018	pint (UK)
	litre (l)	x 1.76	pint (UK)
	litre (l)	x 0.22	gallon (UK)
	litre (l)	x 0.26	gallons (US)
	litre (l)	x 2.11	pints (US)
	gallon (US)	x 4	quarts
	litre dry	x 0.908	quart dry
	litre	x 1.056	quart
	pint	x 0.5047	quart
	litre	x 4.166	cup
	ml/kg	x 0.015	fl oz/lb
Temperture	°C	x 0.8 + 32	°F
	°F	-32 x 0.55	°C
Energy	joules	x 0.24	calories
	kcal/kg	x 0.454	kcal/lbm
	cal/kg	x 0.454	mcal/lb
	MJ/kg	x 0.24	mcal/kg
	calories	x 4.184	joules

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