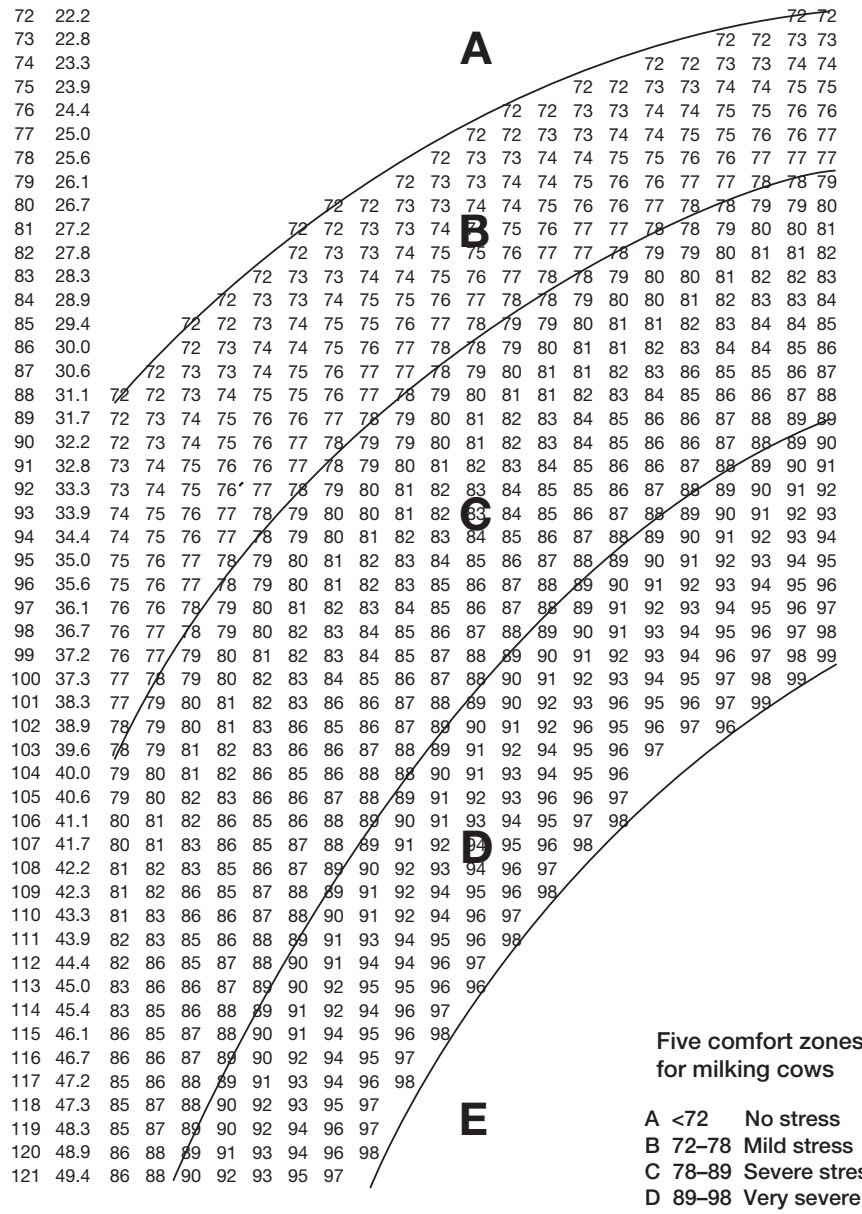
Appendix 1 Temperature Humidity Index

The following table presents the Temperature Humidity Index (THI), calculated from temperature (in degrees Farenheit or Centigrade) and relative humidity (%), highlighting its effect on cow stress and hence performance.

Temperature **Relative humidity**

Deg F	Deg C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
72	22.2																				72	72
73	22.8																		72	72	73	73
74	23.3																72	72	73	73	74	74
75	23.9														72	72	73	73	74	74	75	75
76	24.4												72	72	73	73	74	74	75	75	76	76
77	25.0											72	72	73	73	74	74	75	75	76	76	77
78	25.6										72	73	73	74	74	75	75	76	76	77	77	77
79	26.1									72	73	73	74	74	75	76	76	77	77	78	78	79
80	26.7							72	72	73	73	74	74	75	76	76	77	78	78	79	79	80
81	27.2						72	72	73	73	74	74	75	76	77	77	78	78	79	80	80	81
82	27.8						72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
83	28.3					72	73	73	74	74	75	76	77	78	78	79	80	80	81	82	82	83
84	28.9				72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
85	29.4			72	72	73	74	75	75	76	77	78	79	79	80	81	81	82	83	84	84	85
86	30.0			72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	30.6		72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	86	85	85	86	87
88	31.1	72	72	73	74	75	75	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
89	31.7	72	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	89
90	32.2	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
91	32.8	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
92	33.3	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
93	33.9	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	92	93
94	34.4	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	35.6	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96
97	36.1	76	76	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97
98	36.7	76	77	78	79	80	82	83	84	85	86	87	88	89	90	91	93	94	95	96	97	98
99	37.2	76	77	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	96	97	98	99
100	37.3	77	78	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	97	98	99	
101	38.3	77	79	80	81	82	83	86	86	87	88	89	90	92	93	96	95	96	97	99		
102	38.9	78	79	80	81	83	86	85	86	87	89	90	91	92	96	95	96	97	96			
103	39.6	78	79	81	82	83	86	86	87	88	89	90	91	92	94	95	96	97				
104	40.0	79	80	81	82	86	85	86	88	88	90	91	93	94	95	96						
105	40.6	79	80	82	83	86	86	87	88	89	91	92	93	96	96	97						
106	41.1	80	81	82	86	85	86	88	89	90	91	93	94	95	97	98						
107	41.7	80	81	83	86	85	87	88	89	91	92	94	95	96	98							
108	42.2	81	82	83	85	86	87	89	90	92	93	94	96	97								
109	42.3	81	82	86	85	87	88	89	91	92	94	95	96	98								
110	43.3	81	83	86	86	87	88	90	91	92	94	96	97									
111	43.9	82	83	85	86	88	89	91	93	94	95	96	98									
112	44.4	82	86	85	87	88	90	91	94	94	96	97										
113	45.0	83	86	86	87	89	90	92	95	95	96	96										
114	45.4	83	85	86	88	89	91	92	94	96	97											
115	46.1	86	85	87	88	90	91	94	95	96	98											
116	46.7	86	86	87	89	90	92	94	95	97												
117	47.2	85	86	88	89	91	93	94	96	98												
118	47.3	85	87	88	90	92	93	95	97													
119	48.3	85	87	89	90	92	94	96	97													
120	48.9	86	88	89	91	93	94	96	98													
121	49.4	86	88	90	92	93	95	97														



Five comfort zones for milking cows

A	<72	No stress
B	72–78	Mild stress
C	78–89	Severe stress
D	89–98	Very severe stress
E	>98	Dead cows

Source: Dr Frank Wiersama (pers. comm. 1990). Dep Agric. Eng., University of Arizona, Tuscon, Arizona, USA

Appendix 2 Conversion of units of measurements

1 Abbreviations

ac	acre	yr	year
mm	millimetre	mg	milligram
cm	centimetre	kg	kilogram
m	metre	g	gram
mL	millilitre	J	joules
ppm	parts per million	L	litre
K	kilo or thousands	lb	pound
M	mega or millions	ft	foot
MCal	megacalories	hd	head
MJ	megajoule	sq	square
MT	megatonnes	$	dollar
min	minute	c	cent
ha	hectare	<	less than
hr	hour	>	greater than
d	day		

2 Conversion of Imperial units to metric units

Length:	1 inch = 25.4 mm
	1 foot = 30.5 cm
	1 yard = 0.91 m
	1 mile = 1.61 km
Volume:	1 cu ft = 0.028 m^3
	1 pint = 0.57 L
	1 gallon = 4.54 L
	1 bushell = 36.4 L
	1 acre foot = 1.23 ML (megalitre)
Area:	1 acre = 0.40 ha
	1 sq mile = 2.59 km^2
Weight:	1 ounce = 28.3 g
	1 pound = 0.454 kg
	1 hundred weight = 50.8 kg
	1 long ton = 1017 kg (2240 lb)
Energy:	1 calorie = 4.19 joules
Density:	1 lb/ft^3 = 0.063 kg/m^3
Rate:	1 gallon/acre = 11.23 L/ha
	1 pound/acre = 1.12 kg/ha
	1 gallon/ton = 4.17 L/t
Pressure:	1 pound/sq in (psi) = 1.45 kPa (kilopascals)
Yield:	1 lb/ac = 1.12 kg/ha

Temperature: 1°F = ((9/5) * C) + 32
1°F = 0.56°C
50°F = 10.0°C
60°F = 15.6°C
70°F = 21.1°C
80°F = 26.7°C
90°F = 32.2°C
100°F = 37.8°C
110°F = 43.3°C

3 Conversion of US units to metric units

Volume: 1 gallon = 3.79 L
1 bushell = 35.2 L
Weight: 1 hundred weight = 45.4 kg
1 short ton = 907 kg (2000 lb)
Milk prices: $10/hundred weight = 22.0 c/L
Forage maize yields @ 30% DM:
25 ton fresh weight/acre = 16.8 t DM/ha
Food energy: 1 % unit TDN = 0.185 MJ/kg DM of metabolisable energy
30% TDN = 3.7 MJ/kg DM of ME
40% TDN = 5.5 MJ/kg DM of ME
50% TDN= 6.4 MJ/kg DM of ME
60% TDN= 7.4 MJ/kg DM of ME
70% TDN= 8.3 MJ/kg DM of ME
80% TDN= 9.2 MJ/kg DM of ME
1 MCal/lb = 9.22 MJ/kg
1 MCal/kg = 4.19 MJ/kg

4 Conversion of other specific country units to metric units

Most countries now use the metric units of measure; however certain countries have their own historical units, which are still used by farmers and advisers.

China

Length: 1 chi = 33 cm
1 li = 500 m
Volume: 1 gongsheng = 1 L
Weight: 1 jin = 500 g

Thailand

Length: 1 nui = 2.1 cm
1 kheup = 25 cm
1 sawk = 50 cm
1 waa = 2 m
1 sen = 40 cm
1 yoht = 16 km
Weight: 1 baht = 15 g
1 tamleung = 60 g
1 chang = 1.2 kg
1 haap = 60 kg
Area: 1 sq waa = 4 m^2
1 ngaan = 400 m^2
1 rai = 1.6 ha

Appendix 3 Currency converter for South-East Asia

Rather than express costs and returns in one currency (conventionally $US dollars), this manual makes use of currencies from various South-East Asian countries. For the reader's benefit, rather than convert them all to a single currency in the text, the following currency converter compares their relative values in February 2005. More up to date conversions can be obtained via the internet from a currency converter located at http://www.xe.com/ucc.

Relative values of selected currencies in February 2005

Country	Currency unit	000 Rp	1 MR	1 Ps	1 Bt	000 VND	1 A$	1 US$	1 RMB
Indonesia	Rupiah (Rp) x 1000	–	2.42	0.17	0.24	0.58	7.09	9.21	1.11
Malaysia	Ringgit (MR)	0.41	–	0.07	0.10	0.24	2.92	3.80	0.45
Philippines	Peso (Ps)	5.94	14.4	–	1.42	3.47	42.2	54.7	0.61
Thailand	Baht (Bt)	4.18	10.1	0.70	–	2.44	29.7	39.5	4.66
Vietnam	Dong (VND) x 1000	1.72	4.2	0.28	0.41	–	12.1	15.8	0.12
Australia	A$	0.14	0.34	0.02	0.04	0.08	–	1.30	0.16
United States	US$	0.11	0.26	0.02	0.03	0.06	0.77	–	0.12
China	Rendimbi (RMB)	8.99	2.18	0.15	0.21	0.52	6.37	8.28	–

Appendix 4 Vitamins and minerals required by dairy cows

Vitamins required by dairy cows

Vitamin A

Vitamin A (retinol) is a component of the visual pigments in the eye. It is also involved in the formation of tissue and bone and is required for growth, milk production and reproduction. Excess vitamin A is stored in the liver for up to three to four months.

Vitamin A is formed from dietary carotene in the intestinal wall. Most of the vitamin A requirement is met by the consumption of grasses. Deficiencies of vitamin A are uncommon in forage-fed cattle but can occur in cattle fed diets high in cereals or cereal straws or in calves fed low fat milk replacers low in vitamin A.

Vitamin D

Vitamin D is closely involved with calcium (Ca) and phosphorus (P) metabolism as it is required for Ca and P absorption and deposition within bone. It also stimulates the absorption of calcium from the small intestine. If Ca and P levels are adequate in the diet, the need for vitamin D is small.

Vitamin D is also required for the growth and maintenance of teeth and bone. Vitamin D is used in the prevention of milk fever. However, the effectiveness of vitamin D in treating milk fever is reduced when dietary calcium is too low or too high. The best results are achieved when calcium intakes are in the order of 50 to 70 g calcium/d.

Vitamin D is formed in the skin following exposure to sunlight and is stored in the liver. Deficiencies are rare; however, vitamin D toxicity has been observed in cows given excessive doses of vitamin D during the treatment of milk fever. Vitamin D toxicity results in the calcification of the body's soft tissues (especially the aorta in the heart).

Vitamin E/Selenium

A deficiency of either vitamin E or selenium (Se) leads to muscular dystrophy (white muscle disease) which produces stiffness, uncoordinated movement and in severe cases, death from heart failure. Vitamin E prevents damage to cell membranes.

Both vitamin E and Se have anti-oxidant properties that protect biological systems from degradation and may be important in maintaining reproductive health. Research has found that Se accumulates in body tissues important to reproductive health. There is some suggestion that Se deficiency may cause early embryonic loss. Animals deficient in Se and vitamin E may have suppressed defences against infectious diseases.

Cows supplemented with vitamin E and Se have demonstrated improved conception rate, sperm transport, increased uterine contractions moving towards the oviduct, more robust immune systems (leading to reduced incidence of metritis) and reduced cases of retained foetal membranes and cystic ovaries.

Selenium and vitamin E supplementation is of value in areas deficient in Se when such deficiencies are limiting reproductive performance.

Minerals required by dairy cows

1. Macrominerals

Mineral	Interfering factors	Function	Major sources	Notes
Calcium (Ca)	Phosphorus, vitamin D	Component of bone and teeth, involved in heart, muscle and nerve function and blood coagulation. Essential for milk production	Bone reserves mobilised during mild dietary deficiencies, legumes, grasses	Absorbed from rumen and small intestine at a rate equivalent to the rate needed, regardless of intake. Concentration in milk is constant – milk production is the main variable affecting requirement
Magnesium (Mg)	Potassium, high levels of rumen ammonia	Nerve and muscle function, carbohydrate and lipid metabolism, involved in the secretion of some hormones. Has a role in regulating calcium in blood and bone	Legumes, grasses, causmag, Epsom salts or magnesium chloride	Absorbed in rumen and stored in bone. Bone reserves inadequate to meet daily requirements. Excess Mg excreted in the urine. Excess Mg (greater than 60g/d) causes diarrhoea in cattle and inhibits absorption of calcium and phosphorus
Phosphorus (P)	Calcium, vitamin D, phytic acid	Needed for sound bone and teeth. Vital component in protein, buffer in saliva	Legumes, grasses, bone flour, Di Ammonium Phosphate, monosodium phosphate	Absorbed from the small intestine, also found in bone. Excess P recycled in saliva. P relies on mechanism which mobilises calcium from bone. Excess P interferes with absorption of calcium
Potassium (K)		Essential for enzyme, muscle and nerve function. Major role in carbohydrate metabolism and in nerves and muscles	Grasses, potassium chloride	Absorbed in intestine, excess K excreted in urine. Excess K reduces absorption of magnesium from rumen, especially when sodium is low
Sodium (Na) Chlorine (Cl)		Na necessary for absorption of sugar and amino acids from the digestive tract. Cl has a role in gastric digestion in the abomasum. Na and Cl involved with potassium in osmotic regulation and in acid–base balance	Pasture generally contains plenty of Na. Salt licks	Na and Cl absorbed from digestive tract. Any excess is secreted in urine. The kidney and the lower gut reduce excretion in urine and faeces when Na and Cl are in short supply

2. Microminerals

Mineral	Interfering factors	Function	Major sources	Notes
Copper (Cu)	Molybdenum, zinc, iron, selenium	Required for haemoglobin synthesis and involved in some enzyme and nerve formation. Also required for production of hair pigments and cartilage	Higher levels in clover	Absorbed from stomach, small intestine and large intestine. Toxicity uncommon in adults but can affect weight gain in milk-fed calves
Selenium (Se)	Vitamin E, iron	Important in microbial enzymes and tissue protein as well as antibody production (and therefore immune function)	Higher levels in grasses than clover. Se bullet	Absorbed from small intestines. Deficiency in adults linked with retained placenta and muscular weakness after calving. Muscular dystrophy associated with lack of Se or Vitamin E in calves. Toxicity causes death
Zinc (Zn)		Component of many enzymes and involved in many cellular functions	Zinc oxide, zinc sulfate	Absorbed in small intestine, efficiency of absorption low. Excess Zn lost in faeces. Toxicities rare
Sulfur (S)		Incorporated into the amino acids methionine, cystine and cysteine. Insulin and the vitamins thiamine and biotin also contain sulfur		Deficiency, which is rare, depresses digestion in rumen and food intake. Excess S plus high intake of Mo depresses the availability of Cu
Iodine (I)	Manganese, cobalt, calcium, goitrogens?	Required for synthesis of thyroid hormones that regulate rate of energy metabolism. Goitrogens found in some clovers inhibit hormone synthesis	Iodised salt licks	Absorbed very efficiently from the intestines. Excess is excreted in kidney. Deficiency causes reduced growth rates, reproductive failure and low milk production
Iron (Fe)	Calcium, phosphorus, copper, zinc	Major component of haemoglobin which is required for oxygen transport in the blood. Storage forms in muscle. Also required by several enzymes		Excess Fe harmful to Cu and phosphorus (P) metabolism. Blood loss from parasite burdens linked to deficiencies
Manganese (Mn)		Integral role in several enzymes. Required for bone and cartilage formation and fat and carbohydrate metabolism. Essential for growth, skeletal development, reproduction		Found throughout the body. Deficiency has been linked to reduced reproductive performance. Excess manganese interferes with Fe metabolism, depressing blood concentrations of haemoglobin
Cobalt (Co)		Component of vitamin B12 synthesised in rumen. All symptoms of deficiency are associated with a malfunction of enzymes that require vitamin B12	More in clover than grasses	B12 enzymes are responsible for propionate use in the liver. Deficiency leads to a loss in weight and milk production. Toxicities rare

Appendix 5 Tables of nutrient requirements

Information from these tables is required when completing Work sheet 4.
Energy requirements for maintenance

Table A5.1 Energy requirements for maintenance
Metabolisable Energy (ME); Total Digestible Nutrients (TDN). (Source: Ministry of Agriculture, Fisheries and Food 1984)

Live weight (kg)	Energy requirements	
	MJ ME/day	kg TDN/day
100	17	1.2
150	22	1.5
200	27	1.9
250	31	2.2
300	36	2.5
350	40	2.8
400	45	3.1
450	49	3.4
500	54	3.8
550	59	4.1
600	63	4.4

Energy requirements for pregnancy

Table A5.2 Average daily energy requirements in the last four months of pregnancy
Metabolisable Energy (ME); Total Digestible Nutrients (TDN). (Source: Ministry of Agriculture, Fisheries and Food 1984)

Month of pregnancy	Daily additional energy required	
	MJ ME/day	kg TDN/day
Sixth	8	0.6
Seventh	10	0.7
Eighth	15	1.1
Ninth	20	1.4

Energy requirements for activity
An allowance for grazing activity has been factored into the maintenance requirements in Table 5.1. In flat terrain, 1 MJ Metabolisable Energy (ME) (or 0.1 kg Total Digestible Nutrients (TDN) per kilometre should be added to provide the energy needed to walk to and from the dairy. In hilly country, this increases up to 5 MJ ME (or 0.4 kg TDN) per kilometre.

Energy requirements for milk production
For analyses of data comprising milk fat and milk Solids-Not-Fat (SNF), milk protein can be calculated as follows:

$$\text{Milk protein (\%)} = \text{SNF\%} - 5.4$$

Table A5.3 Energy needed per litre of milk of varying composition (MJ ME/L)
Metabolisable Energy (ME). (Source: Ministry of Agriculture, Fisheries and Food 1984)

Fat (%)	Protein (%)									
	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4
3.0	4.5	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.0	5.1
3.2	4.6	4.7	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.2
3.4	4.7	4.8	4.9	4.9	5.0	5.1	5.2	5.2	5.3	5.4
3.6	4.9	4.9	5.0	5.1	5.1	5.2	5.3	5.4	5.4	5.5
3.8	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.6
4.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.8
4.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9
4.4	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9	6.0	6.0
4.6	5.5	5.6	5.7	5.7	5.8	5.9	5.9	6.0	6.1	6.2
4.8	5.6	5.7	5.8	5.9	5.9	6.0	6.1	6.1	6.2	6.3
5.0	5.8	5.8	5.9	6.0	6.1	6.1	6.2	6.3	6.3	6.4
5.2	5.9	6.0	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.5
5.4	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.5	6.6	6.7
5.6	6.2	6.2	6.3	6.4	6.5	6.5	6.6	6.7	6.7	6.8
5.8	6.3	6.4	6.4	6.5	6.6	6.7	6.7	6.8	6.9	6.9
6.0	6.4	6.5	6.6	6.6	6.7	6.8	6.9	6.9	7.0	7.1

Table A5.4 Energy needed per litre of milk of varying composition (kg TDN/L)
Total Digestible Nutrients (TDN). (Source: Ministry of Agriculture, Fisheries and Food 1984)

Fat (%)	Protein (%)									
	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4
3.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
3.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
3.4	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
3.6	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
3.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
5.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
5.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5
5.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
5.6	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5.8	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Energy requirements for changes in body condition

Table A5.5 The weight of one condition score on cows of different sizes
(Source: Target 10 1999)

Cow's approximate live weight (kg)	Additional weight to increase by one condition score (kg)
550	44
475	38
400	32

Table A5.6 The amount of energy needed or lost in a 1 kg gain or loss in body weight or condition
Metabolisable Energy (ME); Total Digestible Nutrients (TDN). (Source: Target 10 1999)

Change in body condition	Energy needed to gain 1 kg of weight (MJ ME or *kg TDN*)	Energy available from 1 kg of weight loss (MJ ME or *kg TDN*)
Late lactation gain	44 (*3.1*)	–
Dry period gain	55 (*3.9*)	–
Weight loss	–	28 (*2.0*)

Protein requirements

Table A5.7 Crude protein needs of a cow at different stages of lactation
(Source: Target 10 1999)

Milk production	Crude protein requirements
Early lactation	16–18%
Mid-lactation	14–16%
Late lactation	12–14%
Dry	10–12%

Fibre requirements

Table A5.8 The minimum percentage of fibre needed in a cow's diet for healthy rumen function (using three different measures of fibre)
(Source: Target 10 1999)

Fibre measurement	Minimum amount of dietary fibre (% DM)
Neutral detergent fibre	30%
Acid detergent fibre	19%
Crude fibre	17%

Appetite limits

Table A5.9 Maximum daily dry matter intake of cows (kg/d) as affected by cow live weight and diet Neutral Detergent Fibre (NDF) content
(Source: Linn and Martin 1989)

Live weight (kg)	NDF content (%)											
	25	30	35	40	45	50	55	60	65	70	75	80
100	4.8	4.0	3.4	3.0	2.7	2.4	2.2	2.0	1.8	1.7	1.6	1.5
150	7.2	6.0	5.1	4.5	4.0	3.6	3.3	3.0	2.8	2.6	2.4	2.3
200	9.6	8.0	6.9	6.0	5.3	4.8	4.4	4.0	3.7	3.4	3.2	3.0
250	12.0	10.0	8.6	7.5	6.7	6.0	5.5	5.0	4.6	4.3	4.0	3.8
300	14.4	12.0	10.3	9.0	8.0	7.2	6.5	6.0	5.5	5.1	4.8	4.5
350	16.8	14.0	12.0	10.5	9.3	8.4	7.6	7.0	6.5	6.0	5.6	5.3
400	19.2	16.0	13.7	12.0	10.7	9.6	8.7	8.0	7.4	6.9	6.4	6.0
450	21.6	18.0	15.4	13.5	12.0	10.8	9.8	9.0	8.3	7.7	7.2	6.8
500	24.0	20.0	17.1	15.0	13.3	12.0	10.9	10.0	9.2	8.6	8.0	7.5
550	26.4	22.0	18.9	16.5	14.7	13.2	12.0	11.0	10.2	9.4	8.8	8.3
600	28.8	24.0	20.6	18.0	16.0	14.4	13.1	12.0	11.1	10.3	9.6	9.0
650	31.2	26.0	22.3	19.5	17.3	15.6	14.2	13.0	12.0	11.1	10.4	9.8

Appendix 6 Exercises from the manual

The following exercises are based on a small holder dairy farmer with several feeds available for his herd of milking cows, all at different stages of their lactation cycle. Cows then differ in their levels of milk production and milk composition and their pregnancy status. Information for calculating cow requirements is presented in Chapter 6 and for formulating rations in Chapter 12.

Exercise 1

Using copies of the following Work sheet 4 provided, calculate the energy, protein and fibre requirements of four cows, all in stalls:

A A 550 kg cow in early lactation producing 20 L milk/d containing 3.6% fat and 3.2% protein. She is not pregnant and as she is using body condition to produce milk, she is losing 0.5 kg/day in live weight.

B A 500 kg cow in early lactation producing 17 L milk/d containing 3.6% fat and 3.2% protein. She is not pregnant and her body condition is stable so her live weight is not changing.

C A 500 kg cow in late lactation producing 5 L milk/d containing 4.0% fat and 3.8% protein. She is seven months pregnant and is gaining body condition at the rate of 0.5 kg/d.

D A non-lactating 500 kg cow. The cow is stalled in shed so has no activity allowance. She is nine months pregnant and is gaining body condition at the rate of 1.0 kg/d.

Work sheet 4: To calculate the daily energy, protein and fibre needs of a cow

The cow	Her energy needs (kg of TDN)	Her protein needs	Her fibre needs
Cow live weight **A** ____ kg	For maintenance **I** ____ kg		
Daily activity level Terrain (1-5) **B** ____ kg/km	For activity **J** ____ (From B) X ____ (km) = ____ kg	Early lactation 16–18% Mid-lactation 14–16% Late lactation 12–14% Dry 10–12%	(17% CF or 30% NDF)
Month of pregnancy **D** ____ th Month	For pregnancy (Table 6.2) **L** ____ kg		
Daily milk production Volume **E** ____ Litres Fat test **F** ____ % Protein test **G** ____ %	For milk production (Table 6.3) From E ____ X ____ (kg TDN/L) = **M** ____ kg		
Daily change in body condition gain + loss - **H** ____ kg/cow /day	For or from condition (Table 6.5) ____ (From H) X ____ (kg TDN/kg) = **N** ____ kg		

Total daily needs of this cow:

Energy ____ kg
I + J + L + M ± N

Crude protein ____ %
from above

NDF or CF ____ %
from above

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Exercise 2

A small holder farmer in Thailand has the following feeds available for his milking cows with prices in Thai Baht (Bt):

dry matter (DM); Crude Protein (CP); Crude Fibre (CF); Neutral Detergent Fibre (NDF); Metabolisable Energy (ME); Total Digestible Nutrients (TDN).

Feed	Price (Bt/kg)	DM (%)	CP (%)	CF (%)	NDF (%)	TDN (%)	ME (MJ/ kg DM)
Immature grass	0.8	20	10	30	55	60	9.2
Mature grass	0.6	30	8	35	70	50	7.4
Legume	1.0	25	20	32	65	55	8.3
Corn silage	1.5	28	8	24	50	65	10.1
Rice straw	2.5	90	4	42	75	45	6.4
Formulated concentrate	5.0	90	18	15	25	75	12.0
Corn grain	4.0	85	10	7	8	80	12.9
Cassava chips	2.8	88	2	3	20	80	12.9
Rice bran Gr A	4.5	90	14	13	25	70	11.1
Cottonseed meal	5.2	90	45	13	35	75	12.0

The farmer wants to formulate a ration for Cow B (from Exercise 1). She is in early lactation, non-pregnant and producing 17 L/d of milk, which at 12 Bt/L generates a milk income of 204 Bt/d. The basal forage is immature grass and the main supplement is formulated concentrate. The farmer only wants to feed a total of 5 kg/d of concentrate supplements. This exercise involves using this range of feeds to formulate the cheapest ration for Cow B.

A Feeding 50 kg/d of immature grass plus 5 kg/d of formulated concentrate.
B Substituting 10 kg/d of the grass with legume and still feeding 5 kg/d of formulated concentrate.
C Feeding 50 kg/d of immature grass and substituting 1 kg/d of the concentrate with cottonseed meal.
D Feeding 50 kg/d of immature grass and substituting 1 kg/d of the concentrate with cottonseed meal and 1 kg/d with cassava chips.

Using copies of the following Work sheet 5 provided, calculate the energy, protein and fibre contents of these four rations, to provide the following information about each diet:

- total DM intake
- total TDN intake
- diet CP%
- diet NDF%
- intake limit (using Table 12.1)
- total feed costs
- milk income less feed costs.

Work sheet 5: To calculate the energy, protein and fibre content of a diet

Dry matter	Energy (TDN)	Protein (CP)	Fibre (NDF, CF)
Forage: kg/d X DM % ÷100 = A kg/d	from A X TDN % = F kg/d	from A X CP % ÷100 = J kg/d	from A X NDF/CF % ÷ 100 = O kg/d
Supplement 1: kg/d X DM % ÷100 = B kg/d	from B X TDN % = G kg/d	from B X CP % ÷100 = K kg/d	from B X NDF/CF % ÷ 100 = P kg/d
Supplement 2 kg/d X DM % ÷100 = C kg/d	from C X TDN % = H kg/d	from C X CP % ÷100 = L kg/d	from C X NDF/CF % ÷ 100 = Q kg/d
Supplement 3: kg/d X DM % ÷100 = D kg/d /cow/day	from D X TDN % = I kg/d	from D X CP % ÷100 = M kg/d	from D X NDF/CF % ÷ 100 = R kg/d
Total daily DM intake E A+B+C+D kg Total daily DM intake limit Use T and Table A5.9 or the formula (120÷T) ÷100 X live weight kg	Total daily energy intake F+G+H+I kg	Total daily protein intake N J+K+L+M kg CP % of ratio n N÷E X 100	Total daily fibre intake S O+P+Q+R kg NDF (CF) % of ration T S÷E X 100
Cow requirements (from Worksheet 4))	Total daily energy requirement kg	Crude protein requirement %	Fibre requirement % NDF/CF

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Exercise 3

Using copies of the following Work sheet 6, calculate the cost of the TDN and protein in the four feeds from Exercise 2:

1 immature grass
2 corn grain
3 cassava chips
4 cottonseed meal.

Which feed provides the cheapest source of:

A energy
B protein.

Work sheet 6: The cost of nutrients in feeds (Baht)

Feed 1:

Cost per kg Dry Matter (DM)

	X		X 100	=	A
kg bought		DM %			kg DM bought
	÷		X 100	=	B
Total cost (Baht)		kg DM bought			Bt/kg DM

Cost per kg Total Digestible Nutrients (TDN)

	÷			=	C
Bt/kg DM		TDN %			Bt/kg TDN

Cost per kg of Crude Protein (CP)

	÷		X 100	=	D
Bt/kg DM		CP %			Bt/kg CP

Feed 2:

Cost per kg DM

	X		÷ 100	=	A
kg bought		DM %			kg DM bought
	÷		X 100	=	B
Cost (Bt)		kg DM bought			Bt/kg DM

Cost per kg TDN

	X			=	C
Bt/kg DM		TDN %			Bt/kg TDN

Cost per kg of CP

	÷		X 100	=	D
Bt/kg DM		CP %			Bt/kg CP