Sustainable Agricultural Livelihood Restoration, Rehabilitation and Resilience in Kenya

Training Manual

2.4.4 SUB-MODULE 4: FORMULATION OF CATTLE RATIONS

Cattle production is a serious business. However, in most cases farmers are not able to meet family needs because of low profit margins. High cost of feeds and low levels of production are some of the reasons livestock keepers are not making the expected profits which is attributed to poor diets. About 50-70% of cost of dairy production is made up of cost of feeds. Inadequate nutrition is a major cause of low live-weight gains, infertility and low milk yields in dairy cattle. These problems are directly related to late weaning of calves, delayed time of breeding and low lactation milk yields.

Poor dairy cattle feeding practices result from lack of information, skills and knowledge on modern methods of feeding different classes of dairy stock and at different physiological stages by the farmer. Majority of farmers are not aware of the different nutrient requirements for the various classes of dairy stock which may result to either overfeeding or underfeeding of the dairy cattle and hence wastage of scarce feed resources. Additionally, most farmers are not aware of the quality of the available feed resources and how to use the information of quality of feeds to improve dairy production. Evidently lacking is the ability by farmers to mix the various feed ingredients to meet nutrient requirements for maintenance and production of dairy cattle.

Balanced dairy cattle rations can be formulated using various methods (Pearson square, simultaneous equations, least cost formulation using computer models). Although use of theese methods give more accurate and reliable dairy cattle rations, the methods are complicated and of no benefit to majority of dairy farmers with limited education. This is further compounded by lack of simplified extension materials to enhance farmer's capacity to formulate balanced dairy cattle rations using locally available feed resources.

A dairy cattle with good nutrition status (left) and a poorly nourished (right) (Photo: J. Ouda)

Sustainable Agricultural Livelihood Restoration, Rehabilitation and Resilience in Kenya

Training Manual

Feeds resources commonly available in Kenya (Photos: J. Ouda and J. Muia)

Nutrients required by dairy cattle

Energy. Energy is the fuel that keeps all body functions going. Milk production requires a lot of energy. If energy in the ration is not enough, the cow will lose body condition and for milking cows, milk yield will drop, pregnant cows become ill after calving and the calf is usually small in size.

If there is excess energy in the ration, the cow becomes too fat. Cows that are too fat at calving usually have difficult births, retained placenta, displaced abomasums, suffer from milk fever and ketosis.

Sources of energy are roughages and concentrate supplements fed to dairy cattle. Roughages form the main bulk of the dairy cow ration. Roughages are bulky feeds that have a low weight per unit volume. Generally feedstuffs with more than 18% crude fibre and low digestibility are considered roughages.

A high yielding cow may not have enough capacity to consume the amount of roughage required to supply the total energy required due to rumen size. For this reason, supplementation is recommended. Examples of energy sources (Forages and fodders, agricultural by-products, and concentrates) are shown in Tables 2.42 and 2.43.

Table 2.42. Roughages fed to dairy cattle and their quality

Forage/Fodder	Dry matter (g/kg)	ME Energy (MJ/kg DM)	Crude Protein (g/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
Napier grass	180	8.5	88	5.0	3.0
Rhodes grass	280	8.5	90	-	-
Napier silage	280	9.0	75	-	-
Maize cobs	900	7.5	30	1.2	0.4
Fodder sorghum dry	890	8.9	75	4.0	2.1
Maize silage	320	10.5	80	4.0	2.7
Kikuyu grass	200	9.5	120	-	-
Rhodes hay	850	9.2	80	-	-
Lucerne hay	865	8.5	170	14.0	2.4
Sesbania leaves	260	8.5	260	22.1	2.8
Calliandra leaves	260	8.5	240	11.1	1.4
Leucaena leaves	280	8.4	230	15.5	2.1
Sweet potato vines	100	8.0	160	17.9	2.4
Green maize stalks	300	9	80	5.0	2.5
Maize stover	850	7.5	45	3.5	1.9

Table 2.43. Concentrates and minerals supplemented to dairy cattle and their quality

Concentrate/Mineral	Dry matter (g/kg)	ME Energy (MJ/kg DM)	Crude protein (g/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
High yielder dairy meal	920	12.0	180	-	-
Dairy meal	950	12.0	165	6.0	4.0
Calf pellets	920	12.0	180	-	-
Cotton seed cake	920	13.5	350	1.9	2.0
Maize germ	900	15.5	106	1.0	0.5
Maize bran	900	11.5	115	1.0	2.0
Wheat pollard	900	15.1	160	1.3	9.0
Fish meal (Omena)	880	15.0	470	60.0	32.0
Fish meal (Buta)	900	13.4	400	60.0	20.0

Table 2.43. Concentrates and minerals supplemented to dairy cattle and their quality					
Poultry litter	880	10.6	160	-	-
Urea	950	0.0	2600	-	-
Brewers Yeast	930	12.6	340	1.0	14.0
Brewers grains	210	10.5	254	3.3	5.5
Magic protein	900	11.9	480	-	-
Wheat bran	890	11.2	140	1.4	13.8
Maize meal	860	13.8	102	-	-
Cassava tuber meal	840	15.7	30	3.0	3.5
Lupins	860	14.2	342	-	-
Sunflower seed cake	940	12.5	360	3.0	9.0
Soya bean meal	900	12.4	470	-	-
Molasses	750	12.2	35	9.0	1.0
Maclick super	980	-	-	185.1	110.0
Limestone	100	-	-	340.0	0.2
Dicalcium phosphate	970	-	-	220.0	193.0

Protein. Protein provides the essential chemical building blocks for the body cells and tissues, including muscles, blood, skin, internal organs, and also to make milk. Cows can make protein from non-protein nitrogen containing materials such as Urea and poultry litter. Cows cannot store much protein in their bodies and so it must be supplied in the daily ration in order to maintain high milk production.

If the amount of protein in ration is suddenly reduced, milk production will drop rapidly and the cow will lose weight, growth rate of calves and heifers will be reduced also. Feeding too much protein to dairy cows is wasteful because the excess is broken down by micro-organisms in the rumen and excreted from the body. This is wasteful and is unlikely to happen since protein is very expensive.

Minerals. Minerals are required in small amounts than the other nutrients but are important components of the ration. They are essential for cows to remain healthy and for the body to function properly, for the development and maintenance of strong bones and for successful reproduction and production of milk.

Dairy cows require more of the macro-minerals (Calcium, Phosphorus, Magnesium, Sodium, Potassium, Chlorine, Sulphur) than the micro-minerals (Iodine, Iron, Cobalt, Copper, Manganese, Molybdenum, Zinc, Selenium).If cows do not consume enough of the macro-minerals, this will

cause reduced milk yield, infertility problems, weakness of the bone and increased incidences of non-infectious diseases such as milk fever (Due to insufficient Calcium).

Deficiencies in micro-minerals (Trace elements) can cause a variety of diseases and conditions depending on which mineral is deficient. Cattle grazing in areas around Nakuru usually have Cobalt deficiency and may develop a wasting disease called Nakuritis. They become anemic and eventually die. The forages are deficient of mineral Cobalt because the soils naturally contain very low levels of this micro-nutrient. Special mineral supplements are available for cattle in such areas. Too much of the micro-minerals can cause poisoning.

Two macro-minerals are of particular importance. These are Calcium and Phosphorus and special attention should be given to the two minerals when formulating rations. Legumes tend to have more Calcium and Phosphorus than grasses. Grains are low in Calcium. Young dark green forage tends to have more minerals than old, dry and yellow forages. Most tropical forages are low in Phosphorus.

Extra Calcium and Phosphorus usually need to be provided in the ration over and above that naturally present in the feed and mineral mix, especially for high yielding animals. Tables 2.4.1 and 2.4.2 show examples of sources of mineral salts (Forages and fodders, agricultural by-products, concentrates and minerals).

Vitamins. These are group of substances that are required in the ration in very small amounts for normal function of the body. Insufficient supply of any vitamin results in specific deficiency disease. Vitamins are usually not added to dairy cattle rations because most of them are obtained from green forages and some are made in the rumen by micro-organisms.

Feed additives. A feed additive is defined as a feed ingredient of non-nutritive nature that stimulates growth or other type of performance or improves the efficiency of feed utilization or that may be beneficial in some manner to the health or metabolism of the animal. Examples of feed additives for dairy cattle are anti-helmintics (Dewormers), anti-bloat agents, rumen buffers ($NaHCO_3$, MgO), flavouring agents (Molasses), rumen microbes for fibre digestion (Yea sac) and growth promoters or hormone-like substances. In Kenya, feed additives are not commonly added to dairy cattle rations.

Water. Animals need water for normal functioning of their body. Water is needed to make saliva for swallowing feed and for chewing the cud, for feed to be digested, to cool the body when it is too hot and to remove waste materials from the body in the urine and faeces. In addition a milking cow needs water for milk production.

It takes 5 litres of water to produce 1 litre of milk. Ideally, water should be available to dairy cattle at all times. If this in not possible, a rule of thumb is to supply 1litre of water for every 10 kg of live-weight of the cow plus 1.5 litres of water per 1 litre of milk produced.

Information required in formulation of balanced dairy cattle ration. In the long-term commercial dairy production in Kenya will be promoted through training of dairy farmers, extension workers and feed manufacturers on the use of inexpensive locally available dairy feeds. In the short-term, feed formulation should be simplified.

Available feedstuffs and their quality. One should have a good knowledge of the feedstuffs available within the farm and those purchased from outside the farm. The quality of all available feedstuffs including forages and supplements should also be known. If the information is not readily available feed samples need to be taken for quality determination in a reputable laboratory. Examples of various types of dairy cattle feedstuffs and their quality are provided in Table 2.42 and 2.43.

Sustainable Agricultural Livelihood Restoration, Rehabilitation and Resilience in Kenya

Training Manual

Containers of known weight used to weigh feed resources in a ration (Photo: J. Ouda)

Cost of Feedstuffs in relation to milk prices

For commercial dairy production it is important that profit margins are maintained. This could be achieved by either increasing the levels of production at a rate higher than the increasing cost of production or maintaining levels of production but at a lower cost of production. For this to happen, farmers must be aware of the costs of feedstuffs particularly the commercial concentrates and the price of milk and dairy products. Table 2.44 shows price of milk and cost of feed ingredients in different parts of Kenya.

Table 2.44. Price of milk and feed ingredients in different parts of Kenya (2008)

District	Price of milk (KES/litre)	Cost of maize germ (KES/kg)	Fish meal (KES/kg)	Cost of Maclick super (KES/kg)
Kiambu	20.00-28.00	9.00-10.00	32.00-37.00	83.00-88.00
Nyandarua	12.00-15.00	10.00-10.80	35.00-43.00	85.00-90.00
Bureti	14.00-18.00	10.50-11.00	36.00-45.00	87.00-92.00
Machakos	22.00-30.00	10.00-10.80	35.00-43.00	85.00-90.00

Live-weight of dairy cattle

The amount of feed which will provide adequate nutrients to animals will depend on their body size (live-weight). Farmers are not able to determine live-weight of their cattle because they do not have weighing scales. Table 2.45 gives data which can be used by farmers to estimate live-weight of their cattle from girth measurements.

Estimation of cow body weight using heart girth measurement (Photo: J. Muia)

Table 2.45. Estimation of live-weight (kg) of dairy cattle using chest girth (cm) measurements

Calves		Heifers		Cows	
Girth size	Live-weight	Girth size (cm)	Live-weight	Girth size	Live-weight
45	15	108	112	172	420
47	17	110	118	174	435
49	19	112	124	176	451
51	21	114	130	178	467
53	23	116	137	180	483
55	25	118	143	182	500
57	27	120	150	184	516
59	29	122	158	186	534
61	31	124	166	188	552
63	33	126	174	190	570
65	35	128	182	192	590
67	37	130	190	194	610
69	39	132	198	196	631
71	41	134	206	198	653
73	43	136	214	200	675
75	45	138	222	202	697
77	47	140	230	204	720
79	49	142	240	206	
81	51	144	248	208	
83	55	146	256	210	
85	59	148	264	212	
87	63	150	272	214	
89	67	152	280	216	
91	71	154	290	218	
93	75	156	301	220	
95	79	158	313	222	
97	83	160	325	224	
99	87	162	353	226	
101	92	164	366	228	
103	98	166	378	230	
104	103	168	392	232	
106	106	170	406	234	

Maximum dry matter intake

Animal feedstuff can be divided into two major components namely dry matter and water. The dry matter component consists of organic and inorganic matter. The organic matter consists of carbohydrates (source of energy), lipids and fats (source of energy), protein and vitamins. The inorganic matter is the source of macro- and micro-minerals. Since all nutrients are contained in the dry matter the animal must consume this portion in adequate amounts to obtain the required nutrients. If a feed is high in moisture, the animal may not be able to consume enough of the feed to obtain the required nutrients due to limitation of rumen space. Table 2.46 shows the maximum dry matter intake by dairy cattle of various live-weights.

Dairy cattle under stall feeding (Photo: J. Ouda)

Table 2.46. Estimated maximum daily dry matter intake by dairy cows (kg)

Milk yield (4% Butter-fat)	Cow live-weight (kg)					
	350	400	450	500	550	600
10	10.5	11.0	11.5	12.0	12.5	13.0
15	12.0	13.0	13.5	14.0	14.5	15.5
20	13.5	14.5	15.5	16.0	17.0	17.5
25	15.0	16.0	17.0	17.5	18.5	19.5
30	16.5	17.5	19.0	19.5	20.5	21.0
35	19.0	20.0	20.5	21.0	22.0	22.5
40	21.0	22.0	22.5	23.0	24.0	24.5

Maximum dry matter intake may also be estimated from the following equations. Maximum daily dry matter intake (kg/cow) = 0.025 (Live-weight in kg) + 0.1 (Kg of daily milk yield) or 3.0

– 3.5 % of live-weight of cow. If the butter-fat (BF) content of milk is not different, then the following equation can be used to estimate milk yield at 4% butter-fat:

Kg of 4% BF corrected daily milk yield = 0.4 (Kg of daily milk yield) + 15 (Kg of fat in daily milk yield).

Nutrient requirements for maintenance

The nutrient requirements for maintenance of animals are influenced by their live-weight, activity (e.g. walking long distance) and environmental temperature (too cold or too hot). Table 2.47 shows nutrient requirements for maintenance of dairy cattle of various live-weights.

Table 2.47. Daily nutrient requirements for maintenance of a dairy cow

Cow live-weight (kg)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
350	45.5	294	14	10
400	50.3	318	16	11
450	54.9	341	18	13
500	59.4	364	20	14
550	63.8	386	22	16
600	68.1	406	24	17

Nutrient requirements forgrowth

The amount of nutrients required by an animal is equal to the nutrients in the tissue gained. Nutrients concentrations in deposited tissue are influenced by the animal rate of weight gain and the stage of growth or live-weight. The nutrients required for growth by dairy cattle of various live-weights are given in Table 2.48.

Table 2.48. Daily nutrient requirements for growth of dairy cattle

Live-weight (Kg)	Daily gain (g)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
Calves					
25	200	8.4	84	6	4
30	300	11.3	112	7	4
50	500	27.2	315	10	6
75	600	33.4	387	14	8

Table 2.48. Daily nutrient requirements for growth of dairy cattle					
Heifers					
100	400	26.5	386	15	8
100	500	29.0	422	16	8
100	600	31.5	458	17	9
150	400	35.1	529	17	10
150	500	38.2	575	18	11
150	600	41.3	622	19	11
200	400	43.5	598	19	13
200	500	47.1	648	20	13
200	600	50.8	718	20	14
250	400	51.7	629	21	15
250	500	56.0	682	21	16
250	600	60.4	753	22	16
300	400	60.2	761	22	16
300	500	65.2	824	23	17
300	600	70.3	888	23	17
350	400	69.1	909	23	17
350	500	74.8	985	23	18
350	600	80.7	1062	24	18
400	400	78.5	1078	24	18
400	500	85.2	1169	24	19
400	600	92.0	1263	25	19
450	400	89.0	1276	27	19
450	500	96.7	1387	28	19
450	600	104.6	1500	28	19
Lactating cows					
	1000	35.8	320	-	-

Nutrient requirements for milk production

When feeding a dairy cow the aim should be to maximize milk yield by meeting cow's feed requirements. Requirements for milk production will depend on the amount of milk produced by the cow, energy content of milk which is indicated by fat content (the higher the fat content the higher the energy required). Table 2.49 shows nutrient requirements for producing 1 kg of milk of various butter fat contents.

Table 2.49. Nutrient requirements for production of 1 kg of milk				
Milk BF (%)	ME Energy	Crude protein	Calcium	Phosphorus

	(MJ)	(g)	(g)	(g)
3.0	4.5	78	2.7	1.7
3.5	4.8	84	3.0	1.8
4.0	5.2	90	3.2	2.0
4.5	5.5	96	3.5	2.1
5.0	5.9	101	3.7	2.3
5.5	6.2	107	3.9	2.4

In addition to nutrient requirements for milk production nutrients will also be required to cater for other functions such as reproduction (pregnant cows require more to cater for growth of calf) and growth rate if she is not mature (in case of first calf cows).

Water requirements

The amount of water dairy cattle will drink is influenced by the quantity of dry matter ingested, composition of the diet, characteristics of the water, environmental temperatures and physiological state of the animal. Table 2.50 shows water requirements for dairy cows at different ambient temperatures based on dry matter intake requirements for production of 20 kg milk per day.

Table 2.50. Water requirements for dairy cattle

Temperature ^{o}C							
5		10	15	20	25	30	35
4.4		4.6	4.8	5.0	5.2	5.4	5.6
Live-weight (kg)							
350	59.4	62.1	64.8	67.5	70.2	72.9	75.6
400	63.8	66.7	69.6	72.5	75.4	78.3	81.2
450	68.2	71.3	74.4	77.5	80.6	83.7	86.8
500	70.4	73.6	76.8	80.0	83.2	86.4	89.6
550	74.8	78.2	81.6	85.0	88.4	91.8	95.2
600	77.0	80.5	84.0	87.5	91.0	94.5	98.0

Ration formulation guidelines

Dairy farming is a serious business and therefore farmers need to make profit in order to meet family needs. Feed rations fed to dairy cattle either originate from the farm or are purchased. In order to minimize feed wastage and to overcome the problem of low levels of production, dairy rations need to be efficiently utilized by the animal. A cow fed on balanced ration will utilize the feed more efficiently and hence it production will be better than a cow fed on imbalanced rations. Feed rations that are offered to dairy cows are considered balanced if they provide adequate

nutrients (Carbohydrates, protein and minerals) to meet the animal requirements for maintenance, reproduction, growth and milk production.

Proportions of basal diet and supplement in a dairy cow ration

The cheapest feed for milk production is good quality roughage. However, quality of roughage fed to dairy cattle is usually low resulting in sub-optimal levels of production. Further increase in production can therefore be achieved by the use of supplements. Among the factors influencing the quantities of roughage and supplements offered are their quality and level of production of dairy cattle. Table 2.51 shows simple guidelines on proportions of basal diet and supplements depending on levels of milk production in dairy cattle.

Table 2.51. Proportion of basal diet and supplements in dairy cattle rations

Milk yield (kg/day)	Basal diet DM (%)	Supplement DM (%)
10-14	70	30
15-19	60	40
20-24	50	50
25-29	40	60
30-34	30	70
35-40	20	80

Total mixed rations (TMR's)

Dairy cattle feeding as practiced by most farmers (roughage feeding followed by concentrate feeding at milking), may not meet all the nutrient requirements of the animal. Fluctuations in rumen fermentation and supply of nutrients to the mammary glands occur when basal diet and concentrates are offered to dairy cattle at different times. This has a negative effect on productivity of the animal because requirements are met mostly for one nutrient and not the other nutrient and thus the ration is not balanced. To overcome this problem, a total mixed ration can be formulated at 66% for Rhodes hay, 33% for dairy meal and 1% for Malick Super are recommended (Tables 2.52).

Table 2.52. Total mixed ration made from several feed ingredients (DM basis)

Feedstuff	**%**

Table 2.52. Total mixed ration made from several feed ingredients (DM basis)	
Napier grass	65
Lucerne hay	4
Maize germ	18
Wheat pollard	4
Soya meal	2
Cotton seed cake	6
Maclick super	1
Total	100

Limitations of TMR's

- Lack of technical skills and knowledge by farmer and extension officers
- Narrow feed resource base at farm level
- Cost of feed ingredients, processing and mixing equipment may be high for small scale farmers

Advantages of TMR's

- Nutritional balanced diet is supplied to the animal 24 hours a day for maximum productivity
- Convenience of feeding a single meal per day
- Minimise selection and hence wastage of feed by the animal Proportions of energy, protein and minerals in concentrates

Concentrates are needed to promote better utilization of low quality roughage and increase dairy production. Since availability and cost of commercial concentrates are limiting factors to small holder dairy production, formulation of inexpensive home-made concentrates is a necessity. Various combinations of feed ingredients including energy feed (%), protein (%) and mineral (%) can be compounded depending upon the costs of ingredients and costs per unit protein and energy. An example of how to mix a high yielder home-made concetrate would include maize germ (66%), cotton seed cake (20%), poulyrt litter (8%) fish meal (4%) and Maclick Super (2%).

Formulation of rations using a single pearson square

Assume you want to make a dairy meal with 16% crude protein (CP) using cotton seed cake (CSC) and maize germ (MG). The CSC provides 35% CP while MG provides 10.6% CP. Arrange the information as shown in the square below. In the middle of the square is desired value of the nutrient. On the left are the two ingredients with their nutrient content. Subtract diagonally (lesser from the larger) or disregard the sign.

CSC 35 % 5.4 parts CSC [i.e. 10.6 – 16 = 5.4 (disregard the sign)]

- 16 %
- (desired)
- Maize (10.6 %) 19 parts MG [i.e. 35 – 16 = 19 (disregard the sign)]
- Total 24.4 parts

Mix 5.4 parts of CSC with 19 parts of MG expressed as % (100 kg feed) giving:

- 5.4/24.4*100 = 22.1 % of CSC
- 19/25*100 = 77.9 % of MG

One ingredient must be higher in the nutrient (e.g 35% CP for CSC) than the desired value (e.g. 16 % CP for dairy meal). The other ingredient must be lower in the nutrient (e.g. 10.6% CP for MG) than the desired value for dairy meal. No ration can be mixed with a higher value than the highest of the ingredients or vice versa. This method balances only one nutrient from two feedstuffs at a time

Formulation of rations using several pearson square

In many instances, more than two feedstuffs and for more than one nutrient need to be balanced. A double Pearson square method may be used with four feedstuffs and two nutrients. This is accomplished using three Pearson squares.

Example: Make a ration for a lactating cow of 18% CP and ME of 12.0 MJ/ kg DM of ME using MG (10.6% CP and 15.5 MJ/ kg DM), Poultry litter (PL) (16% CP and 10.6 MJ/ kg DM), Cotton seed cake (35% CP and 13.5 MJ/ kg DM) and Soyabean meal (47% CP and 12.4 MJ/ kg DM).

Normally, two sets of a high energy and a high protein concentrates are chosen. The first two Pearson squares are used to balance for the first nutrient in both sets. The densities of the second nutrient in either mixture are calculated. Then the two mixtures are balanced in the third set for the second nutrient.

Mix 1: CP=18%, ME>12.0 MJ/ kg DM

- MG 10.6% 17 = 70% (MG**)**

  18

CSC 35% 7.4 = 30% (CSC)

- Total 24.4

Note: for ME to be >12.0 MJ/kg DM, MG must be used. For CP = 18%, either CSC or soybean (SBM) can be used.

Compute for ME in mix 1.

MG (70*15.5/100) + CSC (30*13.5/100) =14.9 MJ/ kg DM

Mix 2: CP=18%, ME< 12.0 MJ/kg DM

29= 93.5% (PL)

PL 16%

18%

- SBM 47% 2 =6.5% (SBM)

Total 31

Compute for ME

PL (93.5*10.6/100) + SBM (6.5 *12.4/100) = 10.7 MJ/ kg DM

Mix 3: CP=18%, ME=12.0 MJ/ kg DM

Mix 1 = 14.91.3 = 31.0% (Mix 1)

12.0

- Mix 2 = 10.7 2.9 = 69.0 (Mix 2)

Total 4.2

Calculate ingredient composition

To avoid mixing three times, calculate the ingredient composition of the final mix.

Final mix of raw materials when two nutrients are balanced is shown in Tables 2.53 and 2.54

Table 2.53. Raw materials when two nutrients are balanced

Ingredient	Mix 1	Mix 2	Amount of Mix 1 in Mix 3	Amount of Mix 2 in Mix 3	Final composition of ration
Maize germ	70	0	31.0	0	70*31.0/100 =21.7
Poultry litter	0	93.5	0	69.0	93.5*69.0/100=64.5
Cotton seed cake	30	0	31.0	0	30*31.0/100 =9.3
Soy bean meal	0	6.5	0	69.0	6.5*69.0/100 =4.5

Table 2.54. Check for ME and CP

Ingredient	% In Ration	CP %	ME, MJ/kg DM	CP contribution	ME contribution
Maize germ	21.7	10.6	15.5	2.3	3.4
Poultry litter	64.5	16.0	10.6	10.3	6.8
Cotton seed cake.	9.3	35.0	13.5	3.3	1.3
Soybean meal	4.5	47.0	12.4	2.1	0.6
Total				18.0	12.1

Formulation of rations using an alternative procedure

If the following information is provided, a cow weighing 450 kg and producing 20 kg/day of milk (4% butter fat) is fed on a basal diet of Napier grass supplemented with dairy meal and Maclick super. How much of the Napier, dairy meal and minerals will meet the cows requirements.

STEP 1. From Table 2.53 estimate maximum dry matter intake for a 450 kg cow producing 20 kg of milk (4% butter fat) = 15.5 kg
STEP 2. From Table 2.54 estimate proportions of Napier and dairy meal for a cow producing 20 kg/ day of milk

Napier grass = 15.5*50/100 = 7.75 kg

Dairy meal = 15.5*50/100 = 7.75 kg

STEP 3. From estimate nutrients supplied by the feedstuffs (Table 2.55) and from estimate nutrient requirements by a 450 kg cow producing 20 kg/ day of milk (4% butter fat)

Table 2.55. Nutrients supplied by feeds and requirements to produce 20 kg/day of milk

	DMI (Kg/day)	ME (MJ/kg)	CP (g/day)	Ca (g/day)	P (g/day)
Feedstuffs	15.6	155.8	1938	102.1	64.2
Requirements	15.6	158.9	2141	82.0	53.0
Difference	0.0	-3.1	-203	+20.1	+11.2

STEP 4. Estimate amount of feed to be fed to the cow per day

- Napier = 7.75*1000/180 = 43.1 kg fresh Napier

With 5 % wastage allowance = 43.1 + (43.1*5/100) = 45 kg of fresh Napier

Dairy meal = 7.75 = 8.0 kg

Maclick = 100 g

Formulation of rations using computer software

Feeding standards are considered as minimum; hence the final mix should have at least the stated amounts. The Pearson square and the alternative method cannot give a least cost formulation.

Where more than two feed ingredients are available and more than two nutrients must be balanced and costs must be considered then linear programming (LP) must be used. The technique allows for simultaneous consideration of economical and nutritional parameters. The formulator must have a good understanding of the specifications and the techniques of formulation so as to enable interpretation of results.

Most of the performance drill of linear programming is a black box but it is good to know the basic concept to enable verification, interpretation and reformulation of formulas when necessary.

A host of LP programs are available. In LP the fewer the constraints the more accurate are the results. But because of nutritional considerations these are necessary. However, with each additional constraint, cost of feeds increases.

Advantages of least cost formulation

- Avail cheap supply of nutrients
- Avoid unnecessary costs when one ingredient's price increases
- Determines critical price ranges before reworking the problems