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Study Meeting On Dairy Farming

RECENT ADVANCES IN DAIRY DEVELOPMENT-FEEDING AND NUTRITION

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ABSTRACT

Recent advances in feeding and nutrition of lactating ruminants are discussed with specific reference to the implications in, and opportunities for, improving dairy development programmes concerning buffaloes, cattle and goats in Asia. The available feeds to supply energy and proteins for milk production are native and improved grasses, legumes, crop residues, agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR). These are characterised by considerable variability in nutritive value. Rapid growth in tropical forages justify the need for optimum age of cutting. The efficiency of conversion of feed protein to milk protein is unsurpassed in milking animals, and for dietary energy, dairying ranks second to pigs. Theoretical calculations of nutrient requirements for an indigenous and indigenous X Holstein-Friesian cow suggest that except for improved grasses and legumes, concentrate supplementation is a prerequisite to sustain milk production, persistency and increased lactation length. Present evidence on concentrate supplementation suggests that a flat rate allocation of nutrients is more practical and advantageous than more complex systems of feeding according to yield. This can be achieved by expanded and more concerted use of AIBP, NCFR and especially green leguminous forages such as L. leucocephala, G. sepium and T. alexandrinum at optimum levels with approximately 40 : 60 forage concentrate ratio. The formulation of complete diets based on mixed indigenous feeds and utilisation at the farm level has considerable merit, especially reducing the cost of feeding. Prevailing constraints to feeding and nutrition can be overcome by development strategies that can stimulate increased fodder production to support all year round feeding systems, wider use of available feeds, and also urea-molasses block licks in innovative feeding systems that can ensure maximum expression of the genetic potential for milk production in all lactating ruminants (buffaloes, cattle and goats). These strategies need to be identified with improved research-extension linkages, support services and adequate marketing outlets to enhance the present level, and future for, economic dairy production and development in Asia.

I. INTRODUCTION

Milk production from buffaloes and cattle, and to a lesser extent goats, represents without exception, a major thrust and often a priority in animal production programmes in the Asian region. There are several reasons for this and include *inter alia* efficiency of protein and energy conversion, demand for milk and milk products, means of generating ready income, effective alternative use of family labour, a valuable entry point for stimulating rural development in the context of social and economic change, cooperative movement, and an important means of promoting integration for the progressive intensification of agriculture in small farm systems. The attraction to the generation of ready income is important and stems from the means to sell fluid milk produced daily, ensuring that cash is simultaneously available. Additionally, participation in dairy production enables wider benefits of alleviating nutrition and improvement in the quality of life of especially of small farmers and landless peasants and agricultural labourers.

For dairy development programmes to be viable and in order that they can be sustained, it is essential that the efficiency of the resources used for this purpose, and the management of lactating animals are maintained at a high level. In particular, it is especially important that prevailing problems in feeding and nutrition of lactating animals (Devendra and Wanapat, 1986) are kept to a minimum, in which there is a high level of feeding and management, consistent with high performance in the animals. The justification for this is associated with two important considerations. Firstly, maximum expression of the genetic potential of lactating animals can only be achieved by sound feeding and management practices that ensure adequate dietary supply of nutrients in quantitative and qualitative terms. Secondly, since the cost of feeding is a major component cost and approximates to 60-70% of the total cost of milk production, it is essential that the nutrients supplied can be efficiently utilised. The situation is critical in the face of rising feed costs, mainly of vegetable and animal protein feeds and also purchased concentrates.

Clearly, precision in the allocation of nutrients and a high efficiency of nutritional management supported by sound husbandry practices are essential to ensure that lactating ruminants can produce high milk yield of good quality economically. The focal points in this task are the feed resources, their judicious allocation and efficient utilisation by the animal. The first two aspects refer to the types, quantity and quality of feeds available, level of supplementation, feeding and management systems that are essential for milk production, constraints to feed supplies, extent of dependence on purchased feeds and effects on animal performance. Efficient utilisation refers to metabolism and patterns of utilisation, influence of type of dietary ingredients, feed efficiency and cost effectiveness in the conversion of nutrients to milk.

The reference to efficient feeding and management is important because of the influence of these on the scale and quality of the milk produced. While dairy merit is important in the animal, the efficiency with which the feed given is converted to milk represents the final reflection of the viability of the enterprise, which in turn is closely associated with the level of economic production. In this respect, the dairy buffalo, cow and goat are very sophisticated animals with quite a remarkable capacity, producing more than their own live weight in terms of milk in a single lactation.

This paper addresses recent advances on feeding and nutrition of lactating ruminants with particular reference to Asia. The discussion will focus on prevailing patterns of feed resource use, allocation of dietary nutrients, rationale for concentrate supplementation, and economic implications of efficient feeding systems, and efficiency of milk production with reference to lactating buffaloes, cows and also goats. It will also discuss the potential application of emerging new concepts concerning the utilisation of dietary nutrients and development strategies in the context of the search for efficiency in the use of existing resources.

II. FEED RESOURCES

(1) Grasses and legumes

The feed resources for lactating ruminants can be grouped into four categories : (i) Native and improved grasses and legumes, (ii) crop residues, (iii) agro-industrial by-products and

(iv) non-conventional feeds. Table 1 provides a list of these categories and identifies examples of the more common feeds.

The native and improved forages listed are common examples that are found in many countries. The former provides a large proportion of the dry matter intake (DMI) of grazing ruminants. In many instances, this base has also been used to sow improved legume species like Centrosema pubescens, Desmodium spp, Pueraria phaseoloides and Stylosanthes into these systems. The results have enabled increased dry matter (DM) production and possibilities of the system supporting an increased number of grazing lactating animals.

Improved grasses have been used without exception in all countries with a dramatic shift in total DM production and quantity of milk producted. Of particular success in this connection are such examples as Guinea grass (Panicum maximum), Napier grass (Pennisetum purpureum) and Setaria sphacelata used either for grazing or in cut and carry systems. Several varieties among these grass species exist and dairy development programmes with their generally greater demand for quantity and quality forages, have greatly benefitted from the use of these. Thus for example, a survey of about 357 farmers in the Milk Collection Centre (M.C.C.) in Jasin, Malacca, Malaysia, indicated that many farmers were very conscious of the importance of feeding good quality grasses such as P. purpureum, para (B. mutica), Guinea (P. maximum) and signal (B. decumbens). Many even travelled outside of their farms to obtain cut fodder (Hassan Wahab and Devendra, 1983) to ensure that high milk production can be sustained.

Of even greater significance is the increasing trend to include the use of a variety of legumes. These not only include pasture legumes such as those that have been referred to, but also a variety of shrubs and fodder trees. These include Acacia spp., Albizia lebbek, Cajanus cajan, Gliricidia sepium, Leucaena leucocephala, Prosopis and Sesbania grandiflora. Of these, L. leucocephala is possibly the most widely utilised leguminous forage mainly as a source of protein for lactating ruminants.

TABLE 1

COMMON EXAMPLES OF FEED RESOURCES IN ASIA

Native grasses	Improved grasses	Forage legumes	Crop residues	Agro-industrial by-products	Non-conventional feeds
Axonopus compresses	*Panicum maximum*	*Centrosema pubesens*	Cassava leaves	Bagasse Brewers grains	Cassava waste
Arundunaria spp.	*Pernnisetum purpureum*	*Desmodium heterophyllum*	Groundnut vines	Molasses	Palm press fibre Mango seed kernel
Eragnostic viscosa	*Cenchrus ciliaris*	*Pueraria phaseoloides*	Sweet potatoes vines	Coconut cake Guar meal	Poultry litter
Imperata cylindrica	*Brachiaria mutica*	*Stylosanthes spp.*	Maize stover	Groundnut cake Molasses	Neem seed cake Rubber seed meal
			Sorghum stover	Palm kernel cake Palm oil mill effluent	Sal seed cake
Ischaemum muticum	*Brachiaria decumbens*	*Leucaena leucocephala*	Sugarcane tops	Pineapple waste	Sago refuse
Themeda spp.	*Digitaria decumbens*	*Cajanus cajan*	Rice straw	Rice bran	Tea waste
	Setaria sphacelata	*Sesbania grandiflora*	Wheat straw	Wheat middlings	
		Groundnut vines			
		Gliricidia sepium			
		Calliandra calothyrsus			

Many tropical grasses vary in their capacity to support stocking rates. Additionally, milk production is also influenced by the level of fertiliser application and irrigation. In Cuba for example, improved star grass (Cynodon nlemfuensis) significantly (P < 0.001) increased milk yield at a stocking rate of 5 cows/ha, whereas coast cross 1 Bermuda grass (Cynodon dactylon) and pangola grass (Digitaria decumbens), where only able to support lower stocking rates (Jerez, Menchacha and Rivero, 1986).

High milk producing animals generally require a large intake of metabolisable energy (Dirven, 1965; Stobbs, 1971). In view of the inherent nutrient limitations and bulk in most tropical grasses, increased reliance is generally placed on improved grasses and legumes to meet the nutrient demands of high milk production. Native pastures with concentrate supplementation are generally able to support approximate milk yields of 3-8 kg/day, but this level can be substantially increased to between 5000-8000 l/ha/yr on grass-legume pastures in the wet tropics (Stobbs, 1971; Dirven, 1977). In Malaysia, a comparison of rotational grazing versus stall feeding using Sahiwal-Friesian cattle on leucaena - Brachiaria decumbens pasture without concentrate gave a mean yield of 4.8 kg/cow/day. With concentrate supplementation, total milk yields were increased to between 13665-16345 kg/ha/lactation and also the persistency of lactation (Wong, Wan Hassan and Tan, 1987).

(2) Crop residues

Crop residues are plentiful throughout the Asian region. These are mainly fibrous materials that are by-products of crop cultivation, and because of the intensity and emphasis on crop production, these form a high percentage of the total volume of feeds produced. They are essentially fibrous cellulosic feed materials.

Crop residues generally have a low crude protein content, in the range 3.3-13.3% on dry matter basis. This suggests a basic limitation in some of the residues (eg. bagasse and rice straw) around the borderline of the 6-7% dietary crude protein level required for promoting dry matter intake (DMI). There is also the point that most of the residues are deficient in fermentable energy, reflected by the relatively low organic matter digestibility, and also mineral nutrients.

(3) Agro-industrial by-products

Agro-industrial by-products (AIBP) refer more to by-products derived in the industry due to processing of the main products. They are in comparison to crop residues, less fibrous, more concentrated and have a higher nutrient content. Good examples of AIBP are molasses, rice bran, pineapple waste, palm oil mill effluent (POME) produced from refining the palm oil and coconut cake. For purposes of this paper however, and for reasons of brevity, AIBP are used in a general sense to include crop residues.

(4) Non-conventional feed resources

A fourth category of feeds and one which deserves highlighting are non-conventional feed resources (NCFR). This is because of the underestimated potential value and demonstration especially in feed deficit situations like India and Pakistan, that they can make a significant contribution to meeting part of the dietary needs of ruminants. For these reasons, NCFR have been identified separately from crop residues and AIBP although they can be components of both these feed categories.

NCFR refer to all those feeds that have not been traditionally used in animal feeding and or are not normally used in commercially produced rations for livestock. Defined in this manner, the NCFR embrace a wide diversity of feeds that are typical of, and abundant in Asia. A feature about these ingredients is that whereas the traditional feeds of crop origin tend to be mainly from annual crops, the NCFR include commonly, a variety of feeds from perennial crops and feeds of animals and industrial origin.

The term NCFR has been frequently used to describe such new sources of feedstuffs as palm press fibre (oil palm by-products), single cell proteins, and feed material derived from agro-industrial by-products of plant and animal origin, poor-quality cellulosic roughages from farm residues such as stubbles, haulms and vines. Other AIBP also exist such as slaughter-house by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption. This list can be extended to derivatives from chemical or microbial processes, as in the production of single cell proteins.

The AIBP and NCFR are of three broad categories :

(i) energy rich feeds from bananas, citrus fruits, pineapple, sugarcane and root crops (eg. banana waste and molasses).

(ii) protein supplements such as oilseed cakes and meals, animal by-products, by-products from the food industries and fishmeals (eg. coconut cake and feather meal).

(iii) by-products from cereal milling and palm oil refining (eg. rice bran and POME).

Table 2 sets out the more common examples of crop residues and agro-industrial by-products commonly found throughout the Asian region. In the absence of more complete data on cell wall content, the average crude fibre contents are indicated.

Particular reference is made in the last column on table 2 to NCFR. These have been identified separately, because of their underestimated potential. From field, plantation and tree crops alone, the total annual availability is approximately 432 million tonnes. Of this total, about 190 million tonnes or 44.0% are non-conventional feeds, which represents an enormous reservoir of potentially useful feeds (Devendra, 1985).

III. PRIORITIES FOR USE

Table 3 summarises the priorities for using AIBP and NCFR in Asia according to their potential value and importance especially to individual species of animals. It categorises the broad types of feeds, their essential characteristics and the main species which currently utilise them.

TABLE 2

NUTRITIONAL CHARACTERISTICS OF SOME EXAMPLES OF CROP RESIDUES AND AGRO-INDUSTRIAL BY-PRODUCTS FOR LACTATING RUMINANTS IN ASIA

Feed source	Moisture (%)	Crude Protein+ (%)	Crude fibre (%)	Organic matter digestibility (%)
Crop residues[1]				
Cassava leaves	73.6-78.8	21.7-26.6	8.1-23.2	55.1-61.0
Groundnut vines	71.3	9.2	24.1	60.0-68.0
Maize stover	12.8-16.3	5.0	28.3	61.0
Rice straw	9.0-9.2	3.3-4.5	28.8-33.6	48.1-56.4
Sugarcane tops	72.0	3.8	38.0	43.0
Sweet potato vines	86.8	13.3	17.2	60.2
Wheat straw	9.0-10.0	3.2-3.6	37.1-41.9	44.6-54.2
By-products[1]				
Bagasse	3.9-4.7	2.9-6.9	10.3-39.3	49.0
Brewers grains	9.8-10.8	24.0-27.4	15.9-17.1	60.0
Cocoa pod husks	89.6	6.0	31.5	45.0
Coconut cake[2]	10.0	18.0	12.0	78.0
Molasses	24.5	1.6	-	90.0
Palm kernel cake[3]	5.7	14.2	20.2	66.8
Palm oil mill effluent	78.0-89.0	9.6	11.5	58.1-64.2
Pineapple waste	6.8	4.9	20.8	76.0
Poultry litter	6.4	40.4-45.7	18.0-21.2	54.2
Rice bran	9.3-11.4	11.4-17.4	10.4-20.0	62.0
Wheat middlings	12.7	20.5	9.0	69.0-71.4

[1] These include non-conventional feeds
[2] Expeller pressed
[3] Solvent extracted
+ On dry matter basis

TABLE 3

PRIORITIES FOR THE UTILISATION BY ANIMALS OF AGRO-INDUSTRIAL BY-PRODUCTS (AIBP) AND NON-CONVENTIONAL FEED RESOURCES (NCFR) IN ASIA
(Devendra, 1987)

	Feed source	Characteristic	Species
1.	Energy and protein concentrates (eg. rice bran, coconut cake, soyabean meal, poultry litter)	High energy High protein	Pigs, poultry, ducks lactating ruminants
2.	Good quality crop residues (eg. cassava leaves)	High protein High energy	Pigs, ducks, lactating ruminants and use as supplements in meat animals
3.	Medium quality crop residues (eg. sweet potato vines)	Medium protein	Pigs, ruminants (meat and milk), camels and donkeys
4.	Low quality crop residues (eg. cereal straws and bagasse)	Low protein Very fibrous	Ruminants (meat and draught), camels and donkeys

Notes : 1) The reference to AIBP includes crop residues
2) Ruminants refer to buffaloes, cattle, goats and sheep.

It can be seen that energy and protein concentrates, good quality crop residues and to a lesser extent medium quality crop residues are particularly useful for lactating ruminants.

IV. EFFICIENCY OF MILK PRODUCTION

The efficiency with which dietary feeds are converted to edible and also fibrous products of economic value to man is an important index and also reflects a ranking order of the capacities of individual species. Expressed very simply, it is a ratio of the output to input.

The accuracy of the index however is determined entirely by the reliability of the data for both output and input. Additionally, the type of index derived is also influenced by the type of units used, biological, financial or physical (Spedding, Washington and Hoxey, 1981).

The efficiency of feed conversion is influenced by several factors and include, inherent genetic capacity, diet quality, level of feeding, processing of feed ingredients, potential response and prices of the products. With dairy animals, the genetic merit is equally important as this relates to the yield of milk and milk solids. In a broader - sense, efficiency of dairy production should necessarily involve not only the inputs and outputs, but also components of reproductive efficiency (age at first breeding, conception rate, breeding interval, numbers born and productive life span) in whole farm situations, as reported by Holmes (1971).

Table 4 provides comprehensive data on efficiencies of conversion for six classes of animals of high genetic potential. Details of how the data were derived are found in the main reference. The table shows that the highest efficiency of conversion of feed protein to food protein are dairy cattle, followed by poultry and egg producing birds, pigs and ruminants producing meat. Concerning feed energy, pigs come first, followed by dairy cattle, poultry and meat producing ruminants.

With dairy cows, the feed conversion efficiency of milk is affected by other factors such as the diversion of nutrients for live weight gain or fat deposition over the productive life span. These

TABLE 4

EFFICIENCIES OF PROTEIN AND ENERGY CONVERSION IN SIX CLASSES OF LIVESTOCK
(University of California, 1974)

Commodity	Apparent efficiency	Gross efficiency	Net efficiency	Protein conversion efficiency	Energy conversion efficiency	Energy cost of protein
	- - - - - - - - - -	- -Unit consumption/unit gain - -				- - - - - - - - - -
Beef	7.5	12.5	16.2	6.0	7.0	2.6
Lamb	8.0	16.0	16.2	3.0	3.0	1.3
Pork	3.3	4.7	6.4	12.0	23.0	6.0
Poultry	2.2	2.9	4.8	20.0	13.0	11.0
Eggs	3.0	3.1	4.0	18.0	15.0	11.0
Milk	0.7	0.7	0.9	23.0	21.0	10.0

effects are demonstrated in Table 5 in recent calculations of feed conversion efficiency over time by Holmes (1988). The data show that at the same live weight, a high-yielding cow is more efficient than a low-yielding cow (despite the higher feed requirement of the high-yielding cow), while at the same yield, a heavier cow is less efficient than a lighter cow. Additionally, young cows are less efficient than older cows, and over the total lifetime, efficiency increases with succeeding lactations.

V. FACTORS AFFECTING THE AVAILABILITY OF NUTRIENTS

(1) Dietary nutrients

The availability of nutrients in quantitative and qualitative terms controls to a very large extent in milk production in lactating animals. It is influenced by the area under uncultivated herbage, age and quality of the grasses or legumes, amount of crop residues, agro-industrial by-products, non-conventional feeds and any inherent limitations in the feeds.

(2) Voluntary feed intake

The extent of the feed resources available in table 1 that are of direct benefit to dairy development as well as access to purchased feeds will determine the scale of the operations. Maximum voluntary feed intake (VFI), determines the animal's genetic potential to utilise nutrients, especially energy and proteins in the feeds. It is an essential prerequisite for high performance. The net energy (NE) absorbed each day is controlled by three different but related parameters (Minson, 1985), and are the quantity of food eaten (I), the proportion of each unit of feed that is digested (D), and the efficiency of the products of digestion (E). This is represented by the equation $NE = I \times D \times E$.

The intake is regulated by interactions between metabolic processes in the tissues and the transactions that occur in the reticulo-rumen (Weston, 1984). The level of intake is governed by the amount of material in the reticulo-rumen, its rate of digestion and the rate of movement from the reticulo-rumen.

DMI is affected by several factors, but essentially through

TABLE 5

FEED CONVERSION EFFICIENCIES FOR COWS OF DIFFERENT LIVE WEIGHTS WITH DIFFERENT YIELDS OF MILK FAT AND IN SUCCESSIVE LACTATIONS, EXPRESSED AS GROSS ENERGETIC EFFICIENCY (GROSS ENERGY IN MILK/GROSS ENERGY IN FEED, %)*
(HOLMES, 1988)

A. Annual feed conversion effiencies

Live weight of cow (kg)	Yield of milk fat (kg/year)	
	160 (3600 litres)	200 (4500 litres milk)
(Zero gain in live weight)		
450	18.1%	20.2%
550	16.4%	18.5%

B. Annual and lifetime feed conversion effiencies

Age (years) (first calving 2 years)	Live weight (Kg)	Yield of milk fat (Kg)	Feed conversion efficiency (%)	
			Annual	Cumulative for whole lifetime
2	420			
3	470	140	16.1	8.1
4	500	170	17.8	12.3
5	500	190	19.3	14.2
6	500	200	19.8	15.5
7	500	200	19.8	16.2

* Calculated assuming that : 1 kg MF = 78 MJ NE;

1 Kg DM = 11 MJ ME

genotype interactions with type and level of feeding and components of the environment. Figure 1 attempts to illustrate these interactions. The effects of the environment are mainly through the feed and that on feed intake is mediated mainly through the animal's metabolism.

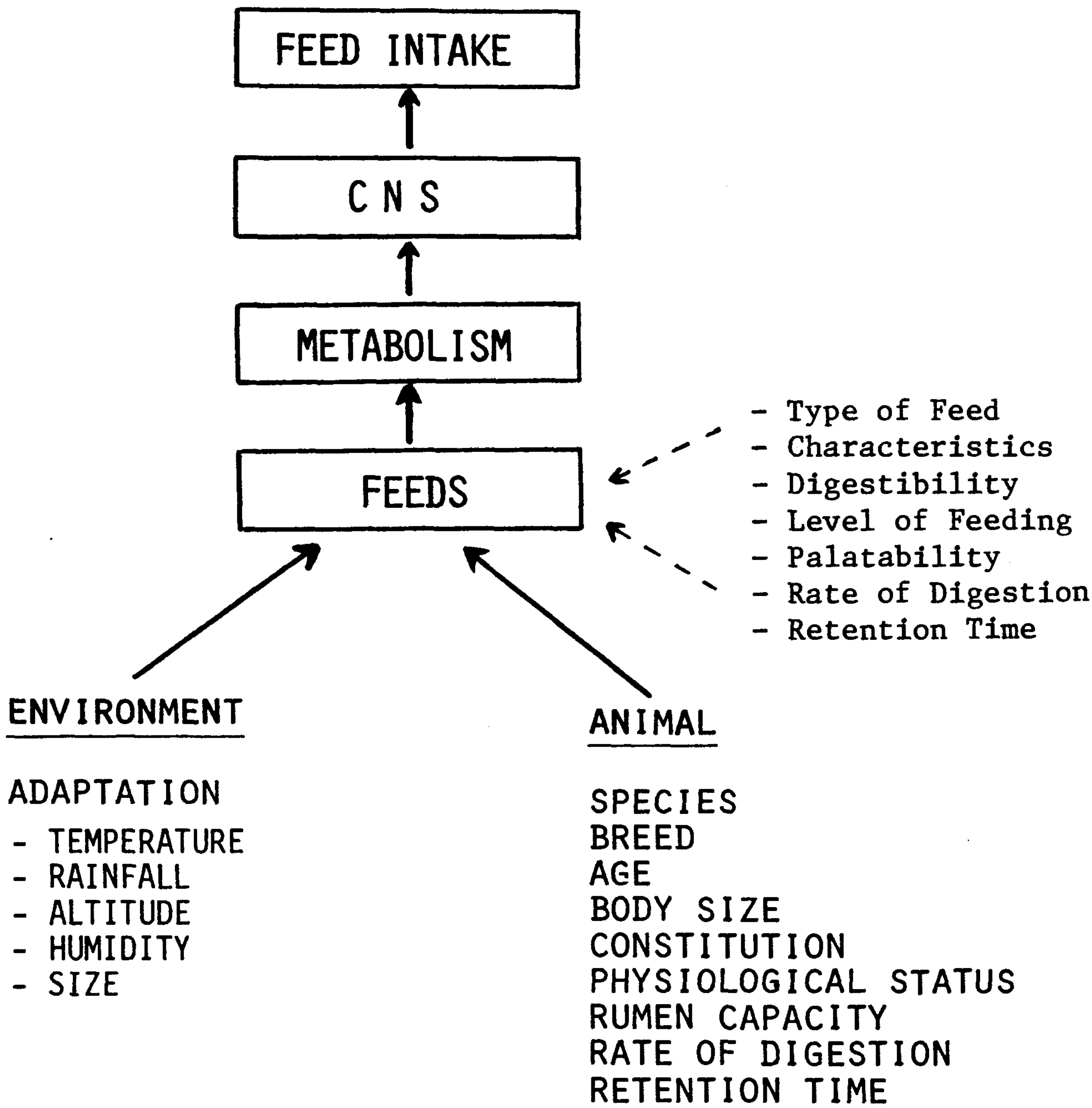
Considerable variation in VFI intake are apparent between and within tropical grasses. Some of the differences are due to differences in digestibility, but other unrelated factors such as those recorded for Panicum varieties may be involved (Minson, 1971). Rate of decrease in digestibility of younger tropical herbage is as high for temperate species (Minson, 1971). It has also been shown that the decline in digestibility with age of tropical grasses was more rapid than tropical legumes which retained relatively high digestibilities at maturity (Milford and Minson, 1966). Differences in vitro digestibility have been reported between genotypes of Digitaria (Strickland and Haydock, 1978). Selection for high in vitro digestibility was successful in producing a high in vivo digestibility of dry matter and superior VFI of Cenchrus ciliaris (Minson and Bray, 1985).

(3) Quality of tropical grasses

It is essential, in view of the rapid growth of tropical forages and variations in nutritive value, that to achieve high VFI and digestibilities, grasses be cut and used at an optimum stage of growth. In general, it is rarely possible to achieve digestibilities beyond 70%. In practical terms, adult ruminants (save the dairy goat) are unlikely to consume beyond 8% of their live weight as fresh grass for digestibilities of mature forage of the order of 40%.

Together with the disadvantage of the restriction of energy uptake imposed by the bulk of tropical grasses, DMI is also limited by the feed-water content of, or the free-water on the ingested herbage, especially in the humid tropics. In the West Indies for example, the dry matter content in Pangola grass of 23.4% during the wet season was very low as compared to 39.3% in the dry season such that the herbage contributed a high proportion of the total

FIGURE 1. FACTORS AFFECTING FEED INTAKE IN RUMINANTS IN THE TROPICS



water consumed (Butterworth, Groom and Wilson, 1961). Similar observations have also been made in Thailand (Holm, 1973). The reduced DMI leads to inadequate dietary energy uptake and occurs when the dry matter content falls below 25%.

(4) Variations in feed quality

Variations in the quality of feedstuffs has a major influence on milk yield and quality. It is dictated by the level of feeding and by the type of feed ingredients : roughages, concentrates or lipids. The effect of milk fat is mediated through variations in the proportions of acetic, propionic and butyric acids in the rumen. The sequence of events is illustrated in Figure 2. While dietary fibre is essential for maintaining rumen function and motility, excessive intake of it which is typical of feeding systems in many parts of Asia limit milk yields without much effect on milk yield. Increasing intakes of roughages fed singly have little effect on the molar proportions of the acids present (Williams and Christian, 1955-57; Bath and Rook, 1963), but with hay-concentrate mixtures where the proportions are kept constant as intake increases, the ratio of acetic to propionic acid narrows (Bath and Rook, 1963). Balch et al., (1954) demonstrated that when the daily hay intake of dairy cows was reduced from 7.3 to 1.8 kg, the milk-fat content decreased from 3.6 to 2.5%. Furthermore, 8.6 kg of ground hay reduced milk-fat percentage even further to 1.9%, emphasising the importance of coarse as opposed to ground roughage.

(5) Forage quality and concentrate supplementation

Forage quality is also important in the context of digestibility and the requirement for additional nutrients. The bulk of the maintenance needs are met from these with possibly a small portion for production. For individual grasses, the relationship between forage quality and the extent of concentrate supplementation, is dependent on its digestibility, and is demonstrated in Table 6 utilising Guinea grass in Malaysia. The digestibility of the concentrate fraction is about 80% and the requirement for concentrates is based on a milk fat content of about 4% for a cow weighing 350 kg live weight.

FIGURE 2. THE EFFECT OF TYPE OF FEEDSTUFFS ON RUMEN PROCESSES AND MILK-FAT (Devendra and Lewis, 1974)

FEEDSTUFF	DIETARY FIBRE (Hay & Straws)	STARCH (Grain)	LIPIDS (Saturated and Unsaturated)
RUMEN	Low conc. of total VFA Relatively low bacterial count High pH (6.5) Slow decomposition	High conc. of total VFA Relatively high bacterial count Low pH (5.7) Rapid decomposition	Low conc. of total VFA Relatively low bacterial count High pH (6.0) Reduced decomposition
	Relatively high acetic acid Low propionic acid Little butyric acid	Relatively less acetic acid More propionic acid Relatively more butyric acid	Reduced acetic acid on low roughage diets, little change on high roughage diets
MILK	Relatively high milk-fat content (milk yield reduced)	Low milk-fat content (milk yield increased)	Variable response on milk-fat content (milk yield increased)

TABLE 6

THE REQUIREMENTS FOR CONCENTRATE SUPPLEMENTATION IN RELATION TO FORAGE QUALITY (KG)
(Devendra, 1975)

Milk yield/day (Kg)	Digestibility of forage dry matter+ (%)			
	55	60	65	70
6	3.2	0.7	-	-
10	4.9	2.5	0.8	-
14	6.6	4.8	1.1	0.3
18	8.2	6.0	3.0	0.7
22	9.8	7.7	5.4	1.7

+ Guinea grass (P. *maximum*)

Table 6 clearly demonstrates that increasing forage quality decreases the requirement for concentrate supplementation, and that with high milk yields and increasing digestibility of forage, the requirement for concentrates is very much reduced. In essence, the efficiency of concentrate utilisation increases with increasing milk yields and improved forage quality. In practice however, very seldom are high digestibilities of around 70% in tropical grasses achieved. Stage of maturity of the forage plant influences its quality more than any other factor; advancing maturity results in decreasing protein content and decreased availability of dietary energy. In practice, a balance thus needs to be formed between dietary fibre and the requirements for supplements that can sustain both milk yields and milk-fat content.

VI. ALLOCATION OF NUTRIENTS FOR MILK PRODUCTION

Lactating buffaloes, cattle and goats generally require high levels of dietary nutrients to meet the demands of production. Meeting the demand at this physiological state represents a particularly challenging task as it directly influences the extent and quality of the milk yields and composition and also the margin of profits due to good nutritional management. Precision in the allocation of nutrients and the manner in which this is provided to lactating animals is therefore especially important.

Using the recommendations for nutrient requirements made by Kearl (1982), Table 7 presents calculations of typical daily and annual nutrient requirements for a lactating indigenous native cow (350 kg live weight) and a Zebu X Holstein crossbred cow (450 kg live weight). Given in the table are the daily and annual requirements for DM, ME, total protein, Ca, P and Vitamin A.

Table 8 presents calculations on the potential supply of the same nutrients from three types of forage sources, native (*A. compressus*, 6 weeks regrowth), improved (*P. purpureum*, 5 weeks regrowth) and *P. purpureum* plus leucaena (leaves plus stems plus pods) at a 30% level of substitution on DM basis.

TABLE 7

DAILY AND ANNUAL NUTRIENT REQUIREMENTS OF INDIGENOUS AND CROSSBRED MILKING COWS

Genotype	DM (Kg)	ME (MJ)	Total protein (Kg)	Ca (Kg)	P (Kg)	Vit. A (1000 IU)
I. Daily requirements						
Indigenous cow+	8.10	16.4	0.721	0.024	0.024	19
Zebu X Holstein - Friesian cow++	9.60	18.6	0.793	0.026	0.026	29
II. Annual requirements*						
Indigenous cow+	2.96	5986	263.1	8.76	8.76	5,840
Zebu X Holstein - Friesian cow	3.50	6789	289.4	9.49	9.45	10,585

+ Average weight is 350 kg, producing 4 kg of milk/day
++ Average weight is 450 kg, producing 8 kg of milk/day
* Tonnes

TABLE 8

THE SUPPLY OF DIETARY NUTRIENTS FROM THREE SOURCES OF FORAGE SUPPLY : NATIVE, IMPROVED AND IMPROVED PLUS LEGUME TO LACTATING INDIGENOUS AND CROSSBRED CATTLE+

Type of forage	ME (MJ)	Total protein (Kg)	Ca (Kg)	P (Kg)
I. INDIGENOUS CATTLE				
Native++	17.01	0.608	0.040	0.340
Improved+++	18.06	0.883	0.035	0.054
Improved + 30% leucaena forage++++	31.19	1.040	0.043	0.042
II. ZEBU X HOLSTEIN-FRIESIAN CATTLE				
Native	20.16	0.720	0.047	0.403
Improved	21.41	1.046	0.042	0.063
Improved + 30% leucaena forage	36.97	1.233	0.056	0.048

\+ Calculations for the two genotypes are based on the DMI in Table 7.
++ *A. compressus*, 6 weeks regrowth
+++ *P. purpureum*, 5 weeks regrowth
++++ Based on 30% substitution of leucaena forage (leaves + stems + pods) on DM basis.

The results of the calculations in Tables 7 and 8 are interesting and several conclusions worthy of discussion. Firstly, the native pasture was barely able to support the ME requirement, was deficient in protein, but adequate in Ca and P supply for both the indigenous and indigenous x Holstein-Friesian cow. Secondly, the improved grass provided adequate ME for the indigenous cow but not the Zebu crossbred, and was able to meet the requirements of protein, Ca and P for both genotypes. With improved grass plus 30% leucaena forage, there was surplus ME, protein, Ca and P, indicating that with this type and level of feeding, high levels of milk production are feasible.

The implications of these findings reflect and confirm prevailing nutritional regimes and milk production that are typical of many parts of South East Asia. It is quite clear that native grasses cannot support reasonable levels of milk production from Zebu cattle (3-4 kg/head/day). The implications of this calculation are that when the pasture offered is restricted or the basal roughage is of poor quality, the response to supplementation is markedly increased (Leaver, 1982). The situation becomes more critical with higher producing dairy animals such as Zebu X Holstein-Friesians, purebred Holstein-Friesian cows, milch buffaloes or temperate dairy goats such as the Saanen, the genetic potential of which can only be expressed by feeding systems that can deliver high quality nutrients that can match the increased demands for milk production. Table 9 demonstrates that for each increased level of Holstein blood of 12.5%, 20-25% more feed is required to maintain equal efficiency.

A parallel situation also exists on animals and mixed cropping small farm systems where the average land size is often only up to 1 ha, typical of many parts of Asia. Rice or wheat is the principal crop but some cash crops like maize, cowpea, groundnuts and mungbeans are also grown. The DM availability in these situations is adequate mainly to support 1-2 draught and beef cattle or swamp buffaloes and possibly also 2-4 goats for meat production. Maintenance of milking cows or buffaloes would necessitate forage crops to be grown in addition, either by utilising a small portion of the existing land or by more complete use of the available land such as use of the rice bunds and multi-purpose fence lines which also produce fodder.

TABLE 9

ESTIMATED MILK YIELD AND FEED REQUIREMENTS FOR NATIVE COWS AND VARIOUS CROSSES WITH HOLSTEIN
(McDowell, 1983)

Proportion of Holstein blood	Mature weight (Kg)	Expected milk yield (Kg)	TDN+ required (Kg/day)	Multiples of maintenance
0	350	850	4.2	1.46
1/8	370	1345	5.2	1.60
2/8	400	1840	6.2	1.74
3/8	425	2335	7.0	1.86
4/8	450	2830	8.0	2.08
5/8	500	4015	9.0	2.12
6/8	575	5090	9.8	2.38
7/8	612	5900	10.2	2.45
8/8	650	7000	11.2	2.80

+ Total digestible nutrients

Where farmers have learnt to value dairying as an important means to integrate with mixed cropping which significant economic benefits can be achieved, they will not hesitate to use any idle land away from their farms to grow fodder crops to feed the cows or even travel outside their farm to seek cut fodder for their animals. Thus, in the M.C.C., Jasin, Malaysia, 97% of the farmers who worked on estates where they did not own land or in their farms where land for fodder cultivation was impossible, travelled approximately 4-8 km daily to cut fodder and transport them in 50 kg bundles in motorcycles to feed their animals (Hassan Wahab and Devendra, 1983).

VII. CONCENTRATE SUPPLEMENTATION

(1) Justification for its use

Inadequate nutrients in dietary forages, the limitations imposed by their bulk and the nutrient needs for high milk production necessitate concentrate supplementation. The problems however are to know when this is precisely needed, how much is needed and for what circumstances, how it can be used without being wasteful and or associated with inefficient fat deposition, and how its use can be justified in the context of the available feed resources and predictable and economic milk production.

Concentrate supplementation, (mainly energy and protein) and the justification for its use is associated with six factors :

(i) Scarcity or inadequacy of dietary nutrients for milk production quantitatively and or qualitatively.

(ii) Plentiful supplies of crop residues, AIBP and NCFR.

(iii) Restriction in energy uptake by bulky roughages.

(iv) Relatively low price of alternative mixed feeds, home grown or purchased concentrates.

(v) Increase lactation length and also peristency.

(vi) Associated with (iv), increased milk yield of good quality whose monetary value is greater than the cost of the concentrates required to produce it.

The level of supplementation and the associated cost are important criteria. In Puerto Rico, it has been shown that the intake of tropical grass by lactating cows is negatively correlated with levels of supplementation (maize, urea plus molasses or commerical concentrate), while milk production was consistently increased (Yazman et al., 1982). Since fibre is important not only for rumen function and beneficial effect on milk fat, optimum supplementation is desirable so that grass intake will not decline, and milk production, lactation length and persistency are maintained. Figure 3 illustrates the possible effects of these on typical lactation curves in the milch buffaloes, cows and goats (Devendra, 1979).

Ability to supplement is a very useful opportunity to small farmers especially in the humid tropics where there is a variety of AIBP and NCFR (Tables 2 and 3). The availability of these enables small farmers to meet the requirements of lactating animals and to optimise milk production, not only to meet family requirements but also for commercial sale.

(2) Allocation

Until recently, nutrient allocation for milk production has been based on the energy requirements for maintenance and production. It is now known that the response to increased feeding levels had a curvilinear relationship to plane of nutrition with milk yield and live weight (Broster et al., 1975), and that this produced a greater milk production response (and smaller live weight response) in cows of high than of low potential. Recent reviews on the subject (Leaver, 1988) suggest that flat-rate systems of concentrate allocation where all cows received the same daily amount of concentrates in early and mid-lactation, produced as much milk as more complex systems which fed concentrates according to cow potential and stage of lactation. Recently, Trujillo (1988) has constructed equations for the prediction of concentrate response based on cow potential and the basic feed.

The concept of the benefit of flat rate feeding over feeding according to yield applied to both high and low quality forages fed ad libilum is shown in (Table 10). The main practical problem associated with this task is definition of an optimum level of feeding in relation to forage quality and amount of forage

FIGURE 3. LACTATION CURVE IN THE GOAT COMPARED WITH LACTATION CURVES IN THE BUFFALO AND THE COW

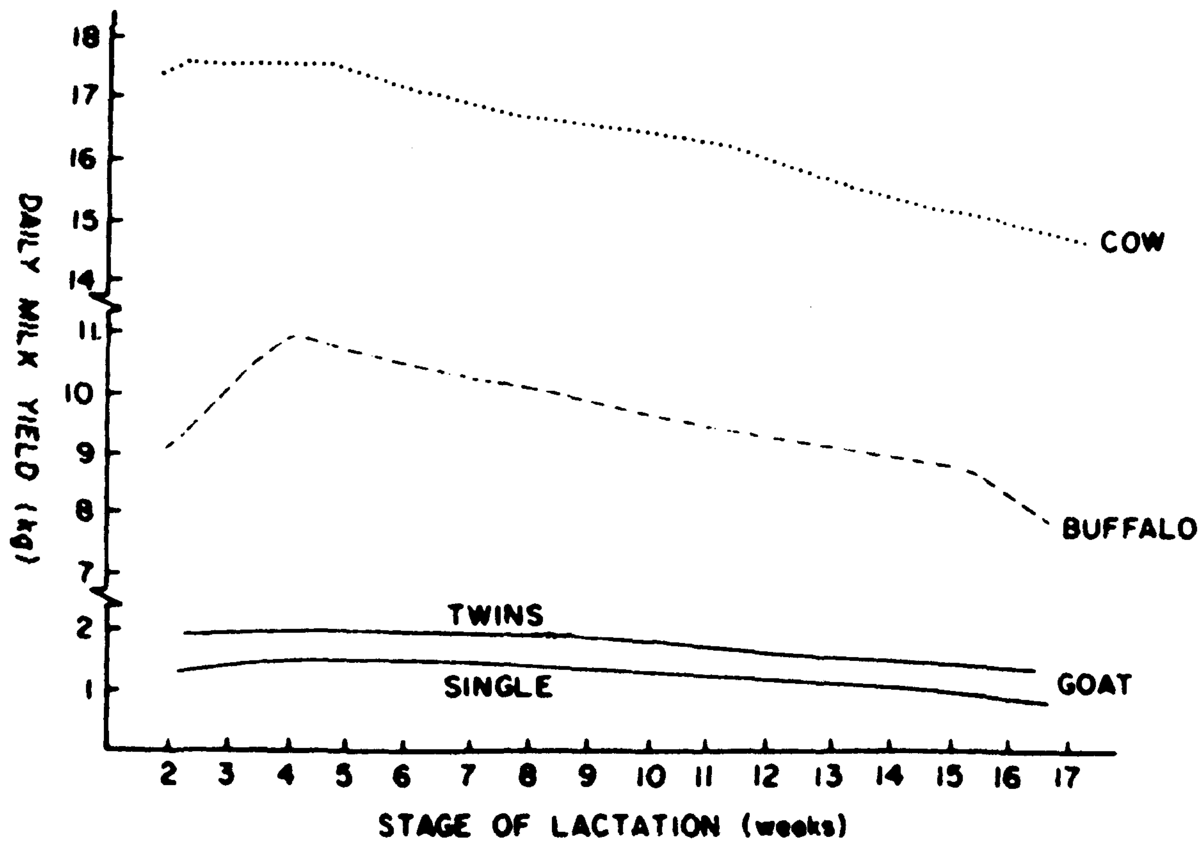


TABLE 10

EFFECT OF CONCENTRATE LEVEL ON SUBSTITUTION RATE OF SILAGE (R) AND ON PRODUCTION RESPONSES IN EARLY AND MID-LACTATION
(Manson, 1986)

Lactation (Weeks)	Concentrate level (Kg DM/day)	R (Kg silage DM/kg concentrate DM)	Milk response (Kg/kg concentrate DM)	Fat + protein response (Kg/kg concentrate DM)	Energy balance* (MJ/day)
3-7	6.1 }	-0.66	+0.35	+0.028	-20
	9.3 }				-8
8-12	6.2 }	-0.41	+1.16	+0.066	-12
	9.4 }				+2
13-17	6.2 }	-0.39	+1.29	+0.081	-9
	9.3 }				+1
18-22	6.2 }	-0.29	+1.06	+0.068	+2
	9.3 }				+17

* Energy balance = ME intake - ME for maintenance and milk production.

available. Low concentrate levels are inadequate for milk yield and persistency, and high levels lead to milk fat depression, poor persistency and are uneconomic. On small farms, these problems become more acute where feed shortages are common and concentrates are expensive to purchase. The determination of this optimum concentrate level has therefore to be calculated from a knowledge of average daily milk yield, type and quality of forage to be fed.

In China, the allocation of concentrates to dairy cattle producing an average 770 kg of milk over a 305 lactation period is somewhat different, but is based on allocation according to milk yield. Maize silage constitute an important roughage source and a typical feeding schedule is as follows :

Up to 15 kg milk yield/day :	20 kg of silage + 4.5 kg hay + 1.5 - 2.0 kg of carrots or turnips and 7.5 kg concentrates/cow/day.
Over 15 kg milk yield/day :	Above schedule + 1 kg additional concentrate/cow/day.

For dairy goats by comparison, with an average milk production of 830 kg over a lactation period of 300 days, the following feeding schedule is applied :

Up to 3-4 kg milk yield/day :	2.5 kg maize silage + 0.8 kg of dried grass + 1.2 kg of concentrate/goat/day.
Over 4 kg milk yield/day :	Above schedule + 0.35 kg concentrate/kg milk yield.

Of special interest is the the fact that both dairy cows and goats are milked thrice per day (0700-0800, 1600-1700 and 2130-2230 hrs) due to the alleged advantage that milk yield is increased by 20-30% in comparison to cows that were milked only twice.

With milch buffaloes, dairy cows and also goats in lactation, concentrate feeding is thus essential and most situations favour a

TABLE 10

FLAT-RATE VERSUS FEEDING TO YIELD FOR SILAGES OF HIGH AND LOW QUALITY
(Taylor and Leaver, 1984)

Silage quality	High		Low	
Concentrate system	Flat	To yield	Flat	To yield
Milk yield (kg day^{-1})	24.4	24.1	21.6	22.0
Fat (g kg^{-1})	40.3	40.6	40.4	41.0
Protein (g kg^{-1})	33.2	33.8	32.4	33.1
Concentrates (kg DM day^{-1})	7.8	7.8	7.7	7.8
Silage (kg DM day^{-1})	9.1	8.7	7.6	7.6

TABLE 11

MILK PRODUCTION IN COWS GIVEN DIETS OF LUCERNE HAY AND MAIZE-BASED CONCENTRATES DIETS PROVIDED SIMILAR AMOUNTS OF DIGESTIBLE ENERGY (164-177 MJ/day)
(Flatt *et al.*, 1969)

Parameter	Concentrate (%)		
	40	60	80
Milk yield (Kg/day	20.4	20.9	18.1
Fat yield (Kg/day)	0.76	0.63	0.46
Protein yield (Kg/day)+	0.63	0.67	0.56
SNF yield (Kg/day)++	1.69	1.73	1.45
Milk energy (MJ/day)	58.3	55.1	43.6
Fat content (g/kg)	35	30	27
Protein content (g/kg)	31	32	31
SNF content (g/kg)	83	83	80

\+ Calculated from given yield and composition of milk

++ SNF = solids-not-fat

TABLE 12

ESTIMATED ANNUAL PRODUCTION OF NUTRIENTS IN POULTRY EXCRETA IN ASIA AND THE PACIFIC (1985, on DM basis)*

Country**	Thousand tons per year			
	Poultry excreta Production	Organic matter	Crude protein (N x 6.25)	TN
Bangladesh	460	336.0	112.0	343.0
Burma	224.4	163.2	54.4	166.6
China	8982.6	6532.8	2177.6	6668.9
India	1069.2	777.6	259.2	793.8
Indonesia	950.4	691.2	230.4	705.6
Kampuchea	39.6	28.2	9.6	29.4
Korea Republic	343.2	249.6	83.2	254.8
Laos	39.6	28.8	9.6	29.4
Malaysia	363.0	264.0	140.8	269.5
Nepal	165.0	120.0	40.0	122.5
Pakistan	627.0	456.0	152.0	465.5
Philippines	376.2	273.6	91.2	279.3
Sri Lanka	46.2	33.6	11.2	34.3
Thailand	508.2	369.6	123.2	377.3
Vietnam	462.0	336.0	112.0	343.0
Fiji	6.6	4.8	1.6	4.9
Papua New Guinea	26.4	19.2	6.4	19.6
TOTAL	**14,689.6**	**10,684.8**	**3,614.4**	**10,907.4**

* Based on an annual production of 90g of faeces/bird/day equivalent to 6.6kg dry matter/bird/year, 4.8kg organic matter/bird/year, 1.6kg crude protein (N x 6.25) bird/year and 4.9kg TDN/bird/year.

** Calculations were based on populations of chickens according to F.A.O. (1986)

TABLE 13

LIFETIME PERFORMANCE OF DAIRY CATTLE FED LEUCAENA LEAF MEAL AND DRIED POULTRY LITTER IN RICE STRAW-BASED DIETS IN THE PHILIPPINES
(Adapted from Trung et al., 1987)

Parameter	Treatments			
	1	2	3	4
Initial live weight (kg)	198.1	165.5	168.1	184.3
Wt before calving (kg)	415.6	391.0	407.8	390.1
Average daily gain (kg)				
- Yearling to breeding	0.61	0.64	0.51	0.52
- Breeding to calving	0.40	0.46	0.41	0.42
Lactation length (days)	270.3	206.5	273.0	208.3
Total FCM yield (kg)	2093.5	1410.5	2140.9	1712.2
Persistency (%)	84.9	89.2	92.9	88.0
Butterfat (%)	4.01	3.87	3.26	3.72
Protein (%)	2.75	2.76	2.81	2.77
Total solids (%)	11.70ab*	11.28ab	11.99a	10.77b
Cost/kg gain (Pesos)+	33.1	23.5	22.1	27.9
Income from milk production (Pesos)+	4668.6	2960.6	6217.8	5300.3

Treatments 1 - 35% RS + 45% L and 20% concentrates
2 - 35% RS + 30% + 15% DPL and 20% concentrates
3 - 35% RS + 22.5% L + 22.5% DPL and 20% concentrates
4 - 35% RS + 65% concentrates

* Row means without a common superscript are statistically significant ($P < 0.05$)

+ Based on a commercial scale (1 Peso = US $0.05) diets involving 20 crossbred over a four year period. AIBP have also been used in calf starter rations (Imaizumi and Devendra, 1984).

The results indicated that although there were no treatment effects, except for total solids (%), inclusion of LLM and DPL gave satisfactory growth rates (0.40 - 0.46 kg/day) and also total milk yields. In particular, the study showed that there were definite economic advantages due to the inclusion of LLM and DPL during both the growth and lactation phases (Table 13). It has been suggested that the combined inclusion of 23% of LLM and 23% of DPL was beneficial.

(5) Use of complete diets

In recent years, increasing attention has been given to an alternative approach to feeding dairy cattle, namely complete diet feeding using mixed processed feeds that can provide a balanced diet for milk production. The complete diet system involves the feeding of dietary ingredients, normally the whole diet to include the forage and concentrate fractions on ad libitum basis. The associated advantages are simplicity of management, mechanisation of feeding, economy of feeding space, safety and flexibility for inclusion of a wide range of ingredients (Owen, 1984). The main disadvantage however is high capital cost. In India, considerable attention has been given to this approach (Reddy, 1986), and preliminary studies on Murrah buffaloes and crossbred cows fed complete diets with 45% cotton straw or 47.5% mixed grass hay produced 6-8 l of milk/head/day, comparable to feeding Napier grass plus concentrates.

(6) Use of dietary fats

In recent years, an alternative means to supply dietary energy has been approached through the use of dietary fats. The results have been variable due to type and level of fats used, type of basal diet and in particular, the proportion of dietary roughage included, the form of roughage inclusion and frequency of feeding.

The effects of these factors have been reviewed (Devendra and Lewis, 1974). In general, feeding fats with a high proportion of C18 fatty acids resulted in unchanged or increased milk yields, whereas with fats rich in C12 and C14 fatty acids, milk yield was unchanged or reduced (Thomas and Rook, 1983). Table 14 taken from a review by Thomas and Martin (1988) shows that saturated fats tended to increase milk fat while less unsaturated fat decreased it. In practice, dietary levels of around 5% are common when fats are used, with an upper limit of 8%.

There are a number of important conclusions in this section on concentrate supplementation. In summarising, these are as follows :

(i) Concentrate supplementation is essential for lactating animals, but the circumstances of its use need to be justified.

(ii) Flat rate allocation is practical and more advantageous then feeding according to yield.

(iii) An optimum level of concentrate feeding is essential, and needs to be determined in relation to forage quantity and quality and milk yield.

(iv) A forage : concentrate ratio of around 60 : 40 - 70 : 30 is desirable.

(v) AIBP and NCFR are potentially advantages in the formulation of mixed diets.

(vi) Complete diets using mixed diets represents an innovative feeding system that has not been adequately explored.

VIII. ECONOMIC IMPLICATIONS

One important objective in improved feeding systems associated with increased milk production is demonstration that the value of the response has a greater monetary value due to the inclusion of supplemental forages. This objective is mediated by increased rates of digestion of the fibrous feeds, reduced cost of feeding and improved nutritional management. The strategy is especially important when weighed against the scarce resources available in small farms, and limited funds to purchase concentrate feeds.

TABLE 14

THE EFFECTS OF VARIOUS FAT SOURCES ON MILK YIELD AND COMPOSITION AND ON FAT AND PROTEIN YIELD (Thomas and Martin, 1988)

Class of fat	Type of fat or oil	Form of inclusion in diet	Responses (%)				
			Milk yield	Fat content	Fat yield	Protein content	Protein yield
	Coconut	Free	+4.3	+9.4	+16.2	-	-
	Red palm	Free	+9.3	+9.9	+18.6	-	-
More saturated	Palm/palmitic acid	Free	+7.9	+14.4	+30.2	-3.6	+9.7
	Tallow	Free	-0.9	+10.7	+9.4	-1.1	-3.2
	Groundnut	Free	+14.7	-1.7	+13.1	-	-
	Cottonseed*	[Free	+1.5	-2.4	+0.9	-	-
		[Free[1]	+15.6	-18.3	-5.3	-	-
Less saturated	Sunflower*[1]	[Free	+0.9	-15.6	-17.3	+0.9	-0.7
		[In seeds	+4.9	-12.6	-15.3	+2.7	-0.2
		[Protected[2]	+7.5	+18.2	+26.3	+4.3	+11.4
	Soya*	[Free[3]	+23.6	-36.8	-22.0	-10.6	+10.4
		[In seeds[3]	+12.9	-1.1	+11.5	-10.6	+0.8
	Soya	Free	-0.7	-0.4	0	-2.2	-3.2
	Soya	Protected	+2.1	+13.0	+13.4	-2.3	-0.2

* Comparisons made within an experiment
[1] Low forage diets
[2] Protected with formaldehyde treated protein
[3] Low fat control diet

Several studies have demonstrated beneficial effects, due to the inclusion of proteinaceous forages, often to replace the protein component in the diet which are often purchased at high cost. Table 15 summarises the results from nine studies, five in India, two in Thailand and one each in Sri Lanka and the Philippines. Earlier studies in India on lactating animals also showed the benefits of forages such as berseem and lucerne (Daniel et al., 1967; Saran and Jackson, 1967; Jackson and Gupta, 1971; Patel and Shukla, 1973). The beneficial effects of supplementary leucaena have also been reported for growing (Cheva-Isarakul and Potikanond, 1985) and lactating (Promma et al., 1985) cattle also in Thailand.

IX. OVERCOMING THE CONSTRAINTS : DEVELOPMENT STRATEGIES

The justification for improved feeding systems for lactating animals is reflected in continuing low per animal production due to poor nutritional management. Low level of nutrition due to a combination of undernutrition, poor nutrition, management variables, nutrient requirements and genetically inferior animals. This situation is the most common and prevails throughout Asia. Inadequate feed supplies to buffaloes influence productivity and this is reflected for example in the ovarian activity of buffalo cows in Indonesia. 35 cows in poor body condition weighing about 275 kg and showing no ovarian activity were alloted to a high or low plane of nutrition for 30 weeks. At the end of this period, 17 of the 18 cows in the high plane of nutrition commenced ovarian activity whereas only 10 out of 17 in the low plane of nutrition did the same (Putu et al., 1983).

Likewise with goats, Table 16 forcefully demonstrates the importance of good nutrition on lactation performance of two outstanding Barbari (meat and milk) and Jamnapari (milk) goats in India. In both breeds, the total milk yields were improved by mean values of between 226 - 315% over five consecutive lactations. A significant finding was that in both breeds low nutrition tended to affect milk yields in the fourth and fifth lactations.

Overcoming the constraints is associated with a number of development strategies that merit attention and discussion. Those that are pertinent to feeding and nutrition are as follows :

TABLE 15

RESULTS OF ECONOMIC BENEFITS OF FORAGE SUPPLEMENTS IN DIETS FOR BUFFALOES AND CATTLE

Feeding regime	Forage supplement	Species	Location	Response	Result	Reference
Wheat straw* + conc	Lucerne + berseem	Buffaloes	India	Milk	Reduced cost/kg SCM milk	Gupta et al., (1983)
Concentrates	Berseem hay	Buffaloes	India	Milk	Reduced cost/kg milk	Chauhan and Chopra (1984)
Rice straw[1]	Gliricidia or Leucaena	buffaloes	Sri Lanka	Milk	Increased margin over costs	Perdok et al., (1983)
Wheat straw* + conc	Leucaena	Calves	India	LW	Reduced cost/kg LW gain	Akbar and Gupta (1985)
Concentrates	Leucaena	Buffaloes	India	Milk	Reduced cost/kg FCM milk	Dharmaraj, Rao and Rao (1985)
Oat silage + conc	Berseem hay	Buffaloes	India	Milk	Reduced cost/kg milk	Chauhan (1986)
Rice straw[2]	Leucaena	Cattle	Thailand	LW gain	Reduced cost/kg LW gain	Cheva-Isarakul and Potikanond (1985)
Rice straw[2]	Leucaena	Cattle	Thailand	Milk	Reduced cost/kg milk	Promma et al., (1985)
Rice straw* + dried poultry litter + conc	Leucaena leaf meal	Cattle	Philippines	LW gained Milk	Reduced cost/kg LW gain Reduced cost/kg milk	Trung et al., (1987)

* Untreated wheat straw
[1] Urea-treated rice straw
[2] Urea-treated or untreated rice straw

TABLE 16

EFFECTS OF PLANE OF NUTRITION ON LACTATION MILK YIELDS OF TWO DAIRY BREEDS OF GOATS (BARBARI AND JAMNAPARI) IN INDIA
(Adapted from Sachdeva *et al.*, 1973)

	Barbari			Jamnapari		
Lactation number	(MH)[a]	(LL)[b]	Difference	(HH)[c]	(LL)[b]	Difference
	----(liters)----		(%)	----(liters)---		(%)
1	101.0	27.8	263.3	153.7	44.0	249.3
2	129.7	30.3	328.1	196.0	58.4	235.6
3	100.4	21.7	362.7	131.8	45.2	191.6
4	106.8	-	-	128.0	-	-
5	109.2	-	-	-	-	-
Mean	110.4	26.6	315.0	160.5	49.2	226.2

[a] Medium-high plane of nutrition
[b] Low-low plane of nutrition
[c] High-high plane of nutrition

(1) Increasing feed supplies

Increased the total feed supply base merits the highest priority since lactating animals require high quality feeds in adequate amounts. Much more needs to be done to cultivate existing land, including waysides and rice bunds, to increase production. This increase can come with reference to such fodders as Napier grass (P. purpureum) and Guinea grass (P. maximum) and also legumes such as calopo (Calopogonium mucunoides), leucaena (L. luecocephala) and pigeon pea (C. cajan).

In many parts of Asia, inadequate production and utilisation of the feed resources from the land, rather than limitations in the availability of land per se, represents the principal constraint to high productivity from farm animals, as well as the viability of small farm systems. Considerable opportunities do exist therefore for increased production of feed from land that has not been, or inadequately cultivated, including the utilisation of dry matter yields in the undergrowth of tree crops. Small farmer dairy development in India for example, has now been expanded to assist some 10 million rurual milk producers who rear about 15 million crossbred cows and improved buffaloes. Implicit in this programme to utilise the available resources more completely is the task to select and breed more productive forages especially berseem and lucerne that can be used in these situations. The approach to more complete utilisation of feeds can also come from making total use of the available agro-industrial by-products.

(2) Improved systems of feeding

Improved feeding practices need to consider appropriate use of potentially important feed ingredients, their innovative use in efficient feeding systems that are consistent with reduced cost of feeding and high per animal performance.

In most parts of the Asian region, there have been an upsurge in the use of cereal straws, and especially their use after nutritive upgrading. Of these, urea-treated or ammonia-treated straw has received the most attention and appears to have good future prospects. The value of its use is associated with increased milkproduction in Sri Lanka (Perdok *et al.*, 1982; 1984). Table 17 summarises the results from the study with Surti buffaloes.

An important strategy apparent in Table 17 concerns the use of other leguminous forages such as leucaena (*L. leucocephala*) and cajanus (*C. cajan*) to offset the dependence on mainly concentrate protein feeds. Thus in Thailand, Promma *et al*. demostrated in a comparison between 6% urea and treated straw, 4% urea treated straw and untreated straw with leucaena treatments that there were no statistical differences in milk yield. The implication of this result is that if the response due to leucaena leaf supplementation is just as effective as urea-treated straw, the former is more appropriate to small farm systems by virtue of easy availability of the forage, reduced cost of feeding and no problems with urea mixing and toxicity. Further examples of the use of forages in feeding systems for ruminants include cassava leaves (*M. esculenta* Crantz) and water hyacinth (*Eichornia crassipes*).

(3) Restricting the export of protein concentrates

A number of countries in the region current export quite considerable amounts of the proteins produced, of vegetables and animal origin. Often this is done at the detriment of much needed dietary proteins to sustain and increased productivity from animals. Examples in this connection are fish meal, cottonseed cake, groundnut cake, coconut cake and palm kernel meal. It is essential that there be some controls over the extent of these exports in order to maximise animal production in the region.

(4) Urea-molasses block licks

The utilisation of urea-molasses blocks licks is an important new innovation and has several advantages. The main objective is to provide urea and therefore ammonia, molasses, macro and micro minerals and possibly even medications on a continuous basis. Additionally, palatability and easy field application are additional advantages. These benefits are now being increasingly

TABLE 17

THE EFFECT OF FEEDING UREA-AMMONIA TREATED STRAW WITH SUPPLEMENTS TO LACTATING SURTI BUFFALOES IN SRI LANKA (Perdok *et al.*, 1983)

Parameter	TRS	Treatments[+]				
		TRS + G (212 CP)[++]	TRS + L (251 CP)	TRS + CC (191 CP)	TRS + G + CC (406 CP)	TRS + L + CC (448 CP)
Milk yield, kg/day	2.41^{a}	2.60^{a}	2.73^{ab}	3.09^{ac}	3.18^{c}	3.36^{c}
Milk fat yield, g/day	221^{a}	242^{a}	238^{a}	311^{b}	319^{b}	325^{b}
Milk fat percentage	9.18	9.34	8.71	10.08	10.03	9.65
Margin over costs (S.L.-RS)	4.07	5.19	4.57	8.34	8.52	8.53

[+] TRS - Urea-ammonia treated rice straw; G - Gliricidia; L- Leucaena; CC - Coconut cake

[++] Amount of crude protein provided

[abc] Means on the same row with different superscripts differ ($P < 0.05$)

extended in real farm situations throughout India. Table 18 demonstrates the results of one study in the Anand area, India. The results indicate firstly that use of the blocks reduced the amount of concentrates fed by 2 - 4 kg/day. Secondly, in buffaloes given straw with supplements, the introduction of the block resulted in market increases in straw intake and milk yield.

(5) Support services

Stronger research-extension linkages and good support services are essential for dairy development. The services include access to, and delivery systems concerned with germplasm, seeds and fertiliser, credit, research and new technology. Training, field programmes and demonstration centres are essential for providing education on all aspects of mixing feeds, improved methods of feeding animals and management of animals.

For inputs to be used to advantage and for proven technology to be transferred successfully, extension assistance needs to be engaged in demonstration work that not only proves the point, but also motivates the farmers into participation and progress. Self-reliance is implicit, and the motivation of farmers is also enhanced by periodic training, timely inputs and creation of marketing opportunities. Successful appropriate technologies are those that would allow the fullest possible use of local resources and would contribute to particular development objectives for dairy production.

X. CONCLUSIONS

Meeting the nutrient demands for high milk production in buffaloes, cattle and goats represents a particularly challenging task. It requires application of the recent advances concerning the feeding of these animals utilising available feed resources in economic feeding systems. Of particular significance in this context are issues of forage quantity and quality and optimum level of concentrate supplementation that can ensure high milk yields commensurate with the genetic potential of milking animals. Increased forage production is essential to support all-year round feeding systems in which the utilisation of a variety of green leguminous forages and complete feeds

TABLE 18

AVERAGE DAILY MILK AND FAT YIELDS IN BUFFALOES BEFORE AND AFTER THE INTRODUCTION OF MOLASSES-UREA BLOCKS IN VILLAGES IN ANAND, INDIA
(Kunju, 1986)

	Milk yield (kg/d)		Milk fat (g/d)	
Village	no block	with block	no block	with block
Alwa	4.8	5.9	330	450
Punadhara	4.0	4.8	270	340
Fulgenamuwada	2.4	3.5	160	280
Hirapura	4.2	5.2	350	480
Banroli	3.6	4.2	270	380
Dehgam	4.3	4.7	310	350

based on AIBP and NCFR are important strategies. These strategies need to be strengthened by improved research-extension linkages, other support services and adequate marketing outlets that can sustain production and the viability of dairy development programmes and economic milk production in the Asian region.

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