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Nutritional Requirements of Dairy Animals for Efficient Milk Production

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ABSTRACT

Feeding management of animals is one of the most important components of dairy farming. Scientific feeding and management of dairy animals favours in maximizing milk production through receiving balanced nutrients like protein, energy, fat, minerals, vitamins and salt in appropriate proportions and at the proper stage. This article highlights about the importance of proper nutrition for milk production, nutrient requirements at various stages of lactating animals, measures to be taken into account to supply various nutrients, the way of formulating diets and feeding management of dairy animals to achieve optimum lifetime milk production which should be followed by every dairy farmer to make dairy business economically viable.

INTRODUCTION

Continuing as the leading milk producing country in the world, India has been bestowed with largest livestock population. Again, cattle and buffalo population constitute about more than 50% of livestock population. Thus, farming of dairy animals has become backbone of livestock sector and contributor to agricultural GDP. Distribution pattern showed that that of livestock among the farmers is more equitable than land. Livestock farming creates the entrepreneurship opportunity

particularly in value addition, processing, feed manufacturing etc. Milk and its products are such commodities whose demands are continuously increasing in India and now, it has become the integral part of supplying nutrition to each household in the country. The demand of milk including its products is also projected to grow further in the future at the domestic and international market.

Feeding of dairy animal is a vital component for milk production and it constitutes more than 70% of total cost of production of milk. Feeding of balanced nutrition should be the key strategy for successful dairy farming. Although status of dairy farming is rapidly changing from allied occupation to main one due to several components namely, decrease of arable land, reach of agriculture yield at the plateau, increase of input cost, increase of demands of animal-based food and many more. But, majority of the farmers are still rearing dairy animals with traditional systems. Therefore, there is an urgent need to upgrade the farmers' knowledge on dairy farming with latest available technologies and recommendations particularly while considering feeding of dairy animals. Any negligence in scientific feeding or feeding of imbalanced ration to the dairy animals is resulting into poor reproductive performance of animals and ultimately, it affects profitability of dairy farming. Feeding dairy animal scientifically is important for maintaining good health and for exploiting their full production and reproduction potential. Proper understanding about scientific feeding at different physiological states is necessary to utilize available nutrients for dairy animals.

IMPORTANCE OF PROPER NUTRITION IN DAIRY ANIMALS

In dairy animals, providing proper nutrition leads to increased milk production and improved milk quality, which can have a significant impact on the income of dairy farmers. Cows require energy to maintain the large body frame, produce milk, grow and support pregnancy. Energy is available from three dietary sources namely carbohydrates, fats and proteins. Fats provide the highest energy per unit of feed, with carbohydrates and protein next. Proper nutrition, through supplying the required nutrients at optimum level, is very important in dairy animal because it helps in maintaining wellbeing and health of animals for ensuring the quality of their produce. The dairy animals should be provided with a mixture of various nutrients as balanced ration which can fulfil minimum nutritional needs.

Dairy animals need basic nutrients like proteins, carbohydrates, fats, minerals and vitamins for ensuring optimum productivity. Improper feeding causes poor growth, low production, poor reproduction, reduced immune response and increased chance of diseases of animals. Controlled feeding, that ensures supply of balance nutrients, usually prevents these problems. It is established that dairy animals produce more milk if supplied with the proper ratio of nutrients.

Provision of balanced nutrition in animals' feed helps to reduce risk of animal diseases and to increase feed efficiency, that means less amount of feed is required to produce milk of same amount. Proper nutrition helps in saving feed costs and reducing environmental footprint through waste minimization. In addition, well fed animal produces high quality product which fetches good market value. Therefore, investing for proper nutrition in feed of dairy animal is a effective way for farmers for improving their bottom line. This, in the long run, can increase

efficiency of animal production and can reduce emissions of greenhouse gas and use of resources like land and water. Additionally, well-nourished animals require minimum antibiotics and other production inputs which favour animal health and environment.

NUTRITIONAL REQUIREMENTS FOR MILK PRODUCTION

The carbohydrate or energy is most critical nutrient need in meeting the production requirements. The main feed resources i.e. agro-industrial by-products and crop residues used for dairy cattle feeding are usually low in energy content. Protein is also an important nutrient. Further, requirements of protein are influenced by microbial activity and rumen pH in animals. While urea is included as nitrogen source, it is very essential to provide them readily available source of carbohydrates. The rumen microbial population allows dairy cow to utilize large quantity of forages and to synthesize protein from the non-protein nitrogen. The dairy cattle are able to meet the requirements of most of their vitamin A, E and D. The macro-minerals should be provided in enough quantities to meet out physiological needs. The trace minerals, which are also important for maximum production by dairy cattle can be provided via mineral mixture. Maintenance allowances for all the nutrients except vitamin A should be increased by 20% during the 1st lactation and 10% during the 2nd lactation for allowing the growth of lactating cows. Daily total dry matter intake varies from 2.2 to 3.0% of body weight (BW). Feed intake of lactating cow is dependent on the factors like cow herself, type of feeds used, climatic conditions, management practices of animals etc. Animal factor includes body size, stage of lactation and milk yield.

The equation for DMI= 0.025 w + 0.1 y; where DMI (kg/day) is dry matter intake; w is live weight (kg) and y is milk yield (kg/day) has been suggested for cows in mid and late lactation. In early lactation (first 10 weeks), the appetite is believed to be reduced by 2-3 kg/day below the values calculated by above equation. The key for effective and efficient milk production is to encourage a cow to eat large amounts of feed during this stage. More DMI resulting from higher nutrient intake gives more milk yield. So the farmers should ensure maximum feed intake.

Dry matter intakes from roughage determine the type and amount of grain needed in the ration. Roughage intakes depend on cow size, forage quality and grain levels. An economical feeding programme always favours more intake of good quality roughages. Lactating cow usually consumes 1.8 to 2.2% of BW daily as DM from dry roughage of average quality. Fibre content of roughages increases with the maturity of forage crop. Forages with high fibre content have lower palatability, decreased protein levels, and have poor digestibility. As the undigested feed cannot pass out of rumen, the cow cannot consume more feed until the feed in rumen is digested. Poor quality forage reduces DMI. Cows generally eat 3% of BW in the form of DM from the excellent hay while only 1.5% from the poor hay.

Quantity of protein and energy present in concentrate mixture is paramount. Feed protein includes two major protein fragments. Protein that is digested in rumen by microbial population is called rumen degradable intake protein (DIP). The feeds rich in DIP are- urea, haylage and raw soybeans. About 55-65% of total protein present in ration should be degradable in rumen. Protein that is not digested by the rumen microbes is known as un-degradable intake protein (UIP) which is often called 'bypass' or 'escape' protein. This protein bypasses rumen with no

digestion. The examples of feeds from plant source which are high in UIP include brewer's grains, roasted soybeans, maize gluten meal and corn distiller's grains etc. The UIP part in the ration should be approximately 35-45%. The level of 35% is most suitable for cows under mid to late lactation. The fresh high producing cow needs 40-45% UIP in ration. Cow fed with high dietary fat requires UIP levels of 45-50%. Proteins from animal source are high quality bypass protein whereas UIP feed from animal source is not very palatable. Energy component can be got from cereal crops. Maize contains the highest energy followed by barley and then, oats. The grain contains high level of starch and after digestion, end product is acidic in nature. This high rumenacidity reduces the digestion of fibre. This may result in 'off feed' and ultimately, a decrease in milk production and fat. By-products like soy hulls, wheat bran, brewer's grains, distiller's grains etc. are low non-fibre carbohydrates (NFC) and they work well in rations for high production. Therefore, to increase energy level in the ration is to add fat but it is costly. But, fat is very expensive to feed to any cow that is not in early lactation or that is not giving above 35 to 40 kg milk. Fats contain over 2.25 times of energy value of the grain. Added fats improve energy balance due to reduction in body weight loss, improvement in persistence of production and help in return to positive energy balance early. The nutrient requirement of different types of dairy animals are presented in Table 1, 2 and 3.

Table 1. Maintenance requirements for DMI, Energy and Protein for lactating animals

BW (Kg)	DMI	TDN (Kg)	ME (Mcal)	MP (g)	RDP (g)	CP (g)
300	6.48	2.62	9.47	191	298	351
400	8.64	3.27	11.82	237	370	436
500	10.8	3.88	14.04	280	438	515
600	12.96	4.47	16.15	321	502	591
700	15.12	5.03	18.19	361	563	663

BW: body weight; DMI: dry matter intake; TDN: total digestible nutrient; ME: metabolizable energy;
MP: metabolizable protein; RDP: rumen digestible protein; CP: crude protein

Table 2. DM, energy and protein requirements per kg milk in cattle

Fat (%)	DMI (Kg)	TDN (Kg)	ME (Mcal)	MP (g)	RDP (g)	RUP (g)	CP (g)
3	0.450	0.290	1.05	51	44	44	96
4	0.510	0.330	1.20	51	50	37	96
5	0.570	0.370	1.34	51	56	30	96
6	0.640	0.410	1.50	51	62	23	96

RUP: rumen un-degraded protein

Table 3. DM, energy and protein requirements per kg milk in buffaloes

Fat (%)	DMI (Kg)	TDN (Kg)	ME (Mcal)	MP (g)	RDP (g)	RUP (g)	CP (g)
6	0.670	0.440	1.58	66	66	46	124
7	0.740	0.480	1.73	66	72	39	124
8	0.800	0.520	1.88	66	78	31	124
9	0.860	0.560	2.02	66	85	24	124

MEASURES TO PROVIDE REQUIRED NUTRIENTS

Proper nutritional management during last trimester of pregnancy ensures faster growth of calf along with attaining an early pubertal age in female calves. To compensate the declined DMI during this stage, high quality densified feeds can be provided to ensure proper intake of nutrients. Bypass fats like calcium salts of fatty acids and bypass proteins like rumen un-degraded protein should be used in rations of pregnant animals at this stage. Good quality 20-25 kg green fodder with 1.0-2.5 kg concentrate should be fed to the dairy animals. Clean and fresh drinking water must be provided *ad libitum*. Dairy animals should be vaccinated at the proper age and seasons to avoid disease incidences. Lactating animals can be dried off 60 days before next calving because the nutrients should be channelized for developing foetus and for repairing wear and tear of the mother. One week prior to the expected calving date, the animal can be shifted to separate and clean calving pen with provision of adequate bedding materials. Bran mash with 1 kg of boiled millet/grains and a handful of jaggery can be provided during this time to avoid constipation. This not only helps in increasing milk production but also helps in expulsion of foetal membrane.

The first milk which is also known as'colostrum' is the first udder secretion of the cow after calving. This is thick and yellow in colour. It contains four to five times more protein and ten to fifteen times more vitamin-A than the normal milk. This is also rich in minerals like Mg, Cu, Fe, and Mn. It also contains several other vitamins like choline, thiamine, riboflavin, pantothenic acid etc. which play vital role in the growth of young calf. Colostrum provides passive immunity to the calves as it contains higher amount of gamma globulins i.e., antibodies. Colostrum has a laxative effect which is helps in voiding the first faeces or meconium. The amount of colostrum to be fed is 1/10thof BW. Quality, quantity and quick supply are three important aspects of feeding colostrum. A bottle with nipple is considered as the easy way to feed the recommended amount of colostrum after birth to every calf. Excess feeding may result in calf scour. Colostrum can be refrigerated and can be used for other calves or for orphan calves.

Water is the most overlooked aspect of calf-raising programme. Water plays important role in rumen development of calves. Water in rumen helps in survival and growth of the microbes. Without water rumen development in calves is slowed. Intake of water helps to increase body weight through increasing dry feed intake at an early stage. Therefore, clean (free from *E. coli, Salmonella* etc.) and fresh drinking water is offered to every calf from first week of their life.

After attaining 6 months age, heifers should be fed with concentrate containing 20% crude protein (CP) and 63% total digestible nutrients (TDN). The heifer usually gets all nutrients they need from about 2 kg of wheat straw, 5-7 kg of maize silage (>30% DM) and 2 kg of concentrate mixture per head per day. Maize (30 kg), soyabean meal (15 kg), wheat bran (20 kg), mustard cake (15 kg), rice bran (17 kg), mineral mixture (2 kg) and salt (1 kg) can be mixed to prepare good quality concentrate mixture. Feeding of feed additives, vitamins etc. has beneficial effects on the performance of heifers.

A cow can be given a 60-65 days' dry period. The coarse textured, chopped forage can be fed to them for avoiding constipation. The TDN and CP content should be 60% and 12-14%, respectively. Dry cow should be maintained with good BCS (body condition score) which may

be varied between 3.5 and 4 before dry period. Cow becomes more efficient in restoring her own body condition during mid-to-late lactation. Cows should neither gain nor lose body condition while dry. Daily concentrate allowance after dry-off depends on quality of roughage availability. When quality of roughage is poor, 2 to 4 kg of concentrate mixture may be allowed daily for maintaining cow's body condition. When roughages are good, but cows are thin, 2 to 4 kg may be given for allowing moderate and gradual weight gain during dry period. Balanced ration for dry cow should contain adequate protein, fibre, minerals and vitamins. A ration that is proper dry cow actually prevents metabolic diseases and retained placenta. Two weeks before calving, the cows or heifers should get grain allowance gradually increasing to the maximum of 1% of their body weight.

For the first few days after calving, no increase of grain should be there above the amount that was offered during pre-calving. Feeding of forage of high quality is required, including as much dry hay as possible. Provision of warm water may be practiced for drinking to reduce the stress of calving. The cow should be properly fed to prevent milk fever and twisted stomachs. Around 3 to 4 days after calving, a feed containing high protein and energy may be provided to them. Proteins stimulate appetite in a fresh cow and also improve feed digestibility. In early lactation, protein requirements are high, at about 19% of the total DM. The protein requirement should be 18% at the peak of milk production.

DIET FORMULATION FOR MILK PRODUCTION

While formulating diets, adequate nutrition must be supplied to the cows for different physiological functions. For this, it is necessary to know nutritive value of feeds, nutritional requirements of animal and the palatability of the feeds. The first step should be to list cow's requirement for dry matter intake, protein, energy, calcium, phosphorus and vitamin A from the appropriate feeding standard tables. Then, available feed ingredients are selected from the feed composition tables. Diet calculation is usually made on a dry matter basis and converted back to fresh feed basis. The main objective in feeding a cow is to allow her for producing milk apart from maintaining her own body weight. The ration of dairy cows, therefore, should have enough nutrients that are needed for maintenance as well as production.

Table 4. Ration for a cow weighing 400 kg, yielding 4-10 kg (6 kg) milk with 4.5% fat

Requirements	DM (kg)	CP (kg)	DCP (kg)	TDN (kg)
Maintenance		0.36	0.25	3.10
Production (6 kg milk)		0.43	0.30	2.10
Total	12	079	0.55	5.20
Feeding regimen (kg)				
Non-legume fodder (8.0 kg)	7.10	0.35	0.21	3.55
Wheat /Paddy straw (3.0 kg)	2.65	0.09		1.06
Concentrate (2.5 kg) (CP-18%, DCP-14%, TDN-70%)	2.25	0.40	0.31	1.57
Total	**12.0**	**0.84**	**0.52**	**6.18**

Maintenance part of ration is dependent on body weight of the cow and the production part depends upon milk yield and fat content of the milk. The main components of a cow's ration are concentrates and roughages. For optimum production, the ration should be balanced and should be given as per the requirements of animals. It has been found that cows produce 3 kg milk with 4.5% fat can be sustained only on crop residues like straw and stover with 3 kg concentrate (Table 4). For easy calculation for farmers, a standard concentrate mixture has been given in Table 5 which can be followed.

Table 5. Composition of concentrate mixture for dairy cows depending on milk yield

Ingredients (kg/100 kg)	Milk yield/d		
	11-15 kg	16-25 kg	26-35 kg
Maize/Wheat/Bajra	30	35	40
Wheat bran	10	10	10
Rice polish	12	12	12
Deoiledricebran	10		
Maize gluten meal		8	12
Mustard cake	20	14	
Soybean meal	5	10	12
Cotton seed			4
Molasses	8	6	5
Mineral mixture	3	3	3
Salt	2	2	2

In the similar way, feeding schedule of cow which gives 4-10 kg milk can be composed of some green fodder with crop residues and 2.5 kg average quality concentrate mixture. This mixture can be fortified with vitamin E, A, D_3 and niacin etc. In addition, 1.5 kg sodium bicarbonate, 1.5 kg by-pass fat and 0.5 kg magnesium oxide may be added in each 100 kg concentrate mixture for getting some beneficial effects on milk production.

CONCLUSION

The provision of proper nutrition through supply of required nutrients for different physiological stages of dairy animals is important for maximizing the profitability of dairy enterprises/ farming along with the assured quality of milk and milk products. While feeding the dairy livestock, the important aspects to be considered are feed intake and the required amount of nutrients like carbohydrates, fats, protein, water, minerals including calcium and phosphorus and other trace minerals with the vitamins. To promote sustainable dairy farming in our country, meeting the nutritional requirements of dairy livestock is the need of the hour. This is being accomplished by choosing good quality fodder (both dry and green), balanced concentrate mixture and also supplementation of mineral mixture and trace mineralised salt along with the dairy animal feed. Concept of bypass proteins and fats are also being incorporated for an improved scientific feeding of high yielding dairy animals.

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