NUTRITIONAL CONSTRAINTS AND STRATEGIES FOR SUSTAINABLE MILK PRODUCTION

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PREFACE

During the golden jublee year of India's independence, Animal Nutrition Society of India is organising VIII Animal Nutrition Research Workers Conference at T.N. University of Veterinary and Animal Science, Chennai. It has been long recognised that the vast livestock population of the country have a potential for improving the economy as well as employment generation among rural poor. Feed resources is the main input to harness the potential of animal productivity but, it is not matching to the nutritional demands of animals with the result the productivity of the animals suffers to a great extent. It has also been realised that availability of traditional feed resources are not going to increase in the coming years, however, the demand for milk, meat, eggs and other animal products will continue to grow due to the increasing human population and changing life style. It is, therefore, the time for scientists, feed manufacturers and planners to discuss the issues threadbare and evolve a strategy to exploit the animal productivity to the maximum, keeping in view our assets in the form of non-traditional feed resources. This conference provides a platform to all those who are concerned for improving the productivity of our livestock so that country can face the challanges at least upto 2020.

The technologies available for enhancing the productivity of livestock, their relevance and the strategies have been discussed by few eminent scientists, feed manufacturers and planners in this volume to enable the participants to deliberate and express their views for further refinement to arrive at a consolidated plan. It is likely that some fruitful conclusions will emerge during the deliberations.

We take this opportunity to thank all the contributors who responded to our invitation. We sincerely thank the faculty of Dairy Cattle Nutrition Division, National Dairy Research Institute, Karnal for their help in bringing out this publication.

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Specialised dairy farming is gaining more popularity in the prominent milk shed areas of India as a result of which about 4 percent per annum milk increase is being achieved, reaching about 65 million tonnes total milk production in the year 1996-97. There is a need to develop region specific policies for breeding, feeding, health control, marketing and management for optimum resource utilization.

NUTRITIONALLY BALANCED DIETS

Traditionally farm animals have played an indispensable role in keeping agriculture on a sound ecological footing by returning nutrients to the soil, producing food, fuel, fertilizer, transport and clothing. But today the conditions are different where both agriculture and animal husbandry are considered as industries and they have to show profits in relation to numerous inputs which involve expenditure.

Technologies for producing milk economically have been developed which can earn more profits. Presently, milk and meat are the important animal source proteins as protective foods for humans. Dairy farms are proliferating because per capita milk availability is about 190g in India and demand in much more than the production.

Indian feeding systems cannot be the same as practiced abroad because most of the feed ingredients are different. Scarce feed resources are required to be utilized cautiously and judiciously. Feeding standards need to be evolved on the basis of long term trials. Specialized dairy farming policy needs to be adopted considering milk as a cash crop, areawise, depending upon the available feed and fodder resources. New feed resources are required to be discovered to augment the feed supply line and to overcome persistent deficit problem. Balanced feeding will not only encourage production but also reduce methane level into the environment. India has 204 million heads of cows, 78 million buffloes representing a total of 282 million heads. Only 2% of the cereal harvest is fed to livestock due to shortage in India (USDA, 1991). Circumstances in India are such that feeding systems for livestock are very different and are mostly based on agro-industrial byproducts. Thus, the feed efficiency (cost wise) is different to convert feed into milk or meat. It is because livestock are reared mostly on straws as a source of roughage. Green fodder is available only in limited quantities. In milkshed areas of India, it is now the practice to stall-fed milch cows and buffaloes practicing a feeding system, using mostly crop residues and green fodders plus concentrate. The farmers income has risen considerably by this changing system.

Feed formulations need to be developed for increased milk prduction point of view. Approximately 10 million crossbred cows of superior germ plasm for milk trait have been generated in the country. It is important that their genetical potential is exploited properly based on cost: benefit ratio. Improved buffaloes also to be fed on similar lines. Underfeeding or low cost imbalanced diets are a common practice, as a result of which farmers are not getting proper return as well as regular income.

Feed efficiency : Feed intake is the main component and rest of the inputs are usually variable depending upon the local conditions. To express this, it is important to feed balanced rations in adequate quantities to estimate total DM intake, concentrate to fodder ratio and feed efficiency in terms of kg DM/Kg milk. Low yielders yielding 5.74 kg milk per day per cow and eating 4.10 kg DM/100 kg body weight, with concentrate : fodder ratio 2.9 : 1, the feed efficiency has been calculated to be 2.13 kg DM intake per kg milk production. On the other hand, cows producing 8.30 kg milk per day and eating 3.46 kg, DM/100 kg body weight with concentrate : fodder ratio of 0.91 : 1.0, the feed efficiency is 1.69 kg DM intake per kg milk yield (Taneja, 1990). The feed efficiency is likely to improve with diets containing higher energy and protein alongwith increased lactation yields. In a study with Karan Swiss cows (Brown Swiss x Sahiwal), with a lactation yield of 3348.48 kg (4.3% fat) in a lactation period of 292 days gives an averge yield of 11.51 kg against the mean DM intake of 12.50 kg per cow per day. The energy intake is equivalent to 0.40 kg TDN intake per kg milk, giving net energy efficiency of 44.99 percent. DM intake per kg milk production is 1.09, with concentrate : fodder ratio being 1 : 3.2 (Arora *et al*, 1978). In an another experiment of the same type, with lactation yield of 3901.05 kg (Fat % 4.4) in 300 days yielded 13.0 kg milk per day per cow. The DM intake was 12.34 kg per day per cow giving feed efficiency is of 0.94 kg DM intake per kg milk production showing NE value of 49.4 percent. Concentrate : roughage ratio was 1:2.29. The results may be much better, provided the persistency of milk yield is maintained. Thus, there is ample evidence to show that higher dietary energy levels are beneficial to increase milk yield along with higher profits (Arora *et al*, 1978; Arora *et al*, 1979). In an another experiment, feed efficiency was 1.26 FCM per kg DM intake. Fat corrected milk yield was 8295 kg (3.5%) in 305 days. The DM intake in that case was 21.6 kg per cow per day (Tessman *et al*, 1991)

Similarly, the lactation yield had been recorded as 1437.38 kg (6.84% fat) in 295 days giving average daily yield of 4.88 kg per day per buffalo. DM intake (concentrate : roughage ratio 1: 2.15) per kg milk was 2.19 kg. The N E value was 49.08 percent. High energy feed is essential for this species because fat content in milk is about 7% as compared to 4.3 % recorded in cows, Fat transfer to milk in buffaloes, yielding about 10 kg milk per day, would be about double as compared to cow milk (Arora *et al*, 1982). Concentrate mixture is being recommended with as high as 24% protein. Fat percentage is likely to fall a little with this type of dietary regimen (Aston, 1992). However, energy balancing of diets is essential as high yielders are usually under negative energy balance during first 5 months of lactation. According to Aston, two third of the increase in milk yield is due to protein and only one-third of the increase in milk yield is owing to energy.

DYNAMICS

Certain approaches which have been adopted now by animal nutritionists, are to evolve feeding standards for livestock for growth, milk production and reproduction. They are based on the understanding of availability, absorption and transport of nutrients into the tissue cells and their utilization. Utilization is the net balance of anabolic and catabolic processes taking place in the tissues. There is a selective entry of nutrients into the tissue cells with corresponding exit of some metabolites maintaining a dynamic equilibrium. Time factor is also important from the point of view of the product formed per unit time. Growth is proportional to protein, fat and carbohydrate deposit which is the difference between the rates of synthesis of metabolites from available nutrients and their catabolism in the whole body. For milk production, the nutritional components are utilized to the extent which accumulate equal to their rates of synthesis. Tissue functions can be well assessed with different test diets and their utilization can be estimated by measuring flux rates and nutrient pool per unit time to derive 24 h net rate of anabolism.

PROTEIN NEEDS

Protein in adequate quantity is a must for maintenance, reproduction, growth and lactation in the rations of dairy cows and buffaloes. Ruminants are normally able to meet their essential amino acid requirements through rumen fermentation. In early lactation, labile tissue proteins provide amino acids for milk production. It is because feed intake is insufficient to meet both protein and energy requirements. Bacterial and protozoal proteins provide 80 percent true protein and rest 20 percent is in the form of nuclic acids-N. Out of 80 percent of bacterial source protein, the digestible protein is 80 percent (NRC, 1989).

Estimates of this tissue labile proteins range from 8 to 22 percent of the body protein which is mobilized into plasma for lactation during first 60 days after calving. This amount of protein in 60 days may be as much as 15 kg.

The basis of meeting the protein requirement is changing which is split into two components. One component is rumen-degradable protein and the other is rumen-undegradable protein. Overall objective is to economize the protein quantity and cost. In this regard, some data are available based on *in vitro* as well as *in vivo* tests on individual ingredient. But tests of both types are required to be carried out on agro-industrial byproducts based on complete rations on long term basis which are being currently used in the country.

In high yielding cows of 5000 kg lactation yield and above, certain individual amino acids e.g. lysine and methionine are to be offered in protected form to maintain persistency (Rogers *et al.*, 1987)

Urea in the diet of ruminants is considered as degradable nitrogen source but it does not provide branched chain fatty acids for the synthesis of essential amino acids. Further, sulphur inadequacy will prevent the synthesis of S-amino acids unless sulphate source is provided in the diet to give N.S. ratio of 10:1. Urea use in the ration of milch animals, particularly when milk yields are above 10 kg per day is contradicted.

DM INTAKE AND ENERGY NEEDS

In high yielding improved cows (15 kg milk per day and above) it is not possible to meet energy requirements within the DM intake limits which results in weight loss and subsequently drop in milk yield. DM intake is affected by many variables such as live weight, level of milk production, stage of lactation, environment, management practices, feeding system, body condition and type and quality of feeds particularly fodders. DM intake during first 3 weeks of lactation is lesser to the extent of 15 percent relative to later intakes. With increase in digestibility of feed, DM intake increases but, the increase is within the limits of 52-68 percent. At higher levels of milk production, the intake is related to energy requirement both in cows and buffaloes. DM intake would vary from 2.25 to 4.32 percent at a particular live weight of a cow. Substitution rate of concentrate mixture over the fodder will vary depending upon the quality, physical form and type of fodder being fed. If the concentrate quantity exceeds 70 percent, forage intake decreases resulting in change of rumen fermentation pattern and in consequence it reduces the milk fat percentage. In other words, concentrate mixture replacement should not exceed 70 percent of total DM intake to avoid drop in milk yield and to avoid fat cow' syndrome problem.

Energy requirements are presented in different units such as TDN, DE, ME, net energy for maintenance, net energy for body gain and NE for lactation. The use of TDN unit is more appropriate because available data from research experiments is more on this unit basis and is directly applicable. The usual conversion rate of 1 kg TDN is equal to 4.409 Mcal DE. NEL expresses the requirments for maintenance, pregnancy, milk production and live weight change. Actual net energy contained in milk is 0.74 Mcal per kg milk containing 4 percent milk fat.

Maintenance requirements of cows would vary depending upon the live weight, breed, milk yield, environmental stress and body activity (stall feeding v/s grazing). This compound mean value is 80 Kcal of NEL per $kgW^{0.75}$. The energy required for gestation has been determined to be 30 percent more to that of maintenance.

In developed countries about 1-2 kg whole soybean (20% fat) is being offered to each cow per day to attain better biological and economical gains. Cotton seed is another source, where as rapeseed is fed in some other countries (Murphy *et al*, 1987)

Long Chain Polyunsaturated Fatty Acids : Certain milk fatty acids, released during intestinal lipolysis, function as antiviral and antibacterial particularly arachidonic acid and docosa hexaenoic acid in addition to their role in growth and visual function in neonatals. They function just like immunoglobulins and considered important from artificial feeding point of view in milk replacers for calves and other neonatals.

NUTRITION AND REPRODUCTION

There are reports from India and abroad that deficient levels of different nutrients in the diet affect not only the growth and milk production but also reproduction. Both cows and buffaloes are equally affected though the former show anoestrous condition more in winter months, whereas the latter exhibits this problem more in summer months. Low levels of protein and energy in the diet badly affect the reproductive system and disturb the oestrous cyclicity. As a result, their post-parturient anoestrous periods are prolonged, thus lengthening their dry periods. Farmers suffer from economic losses as the feed cost is very high. Even the number of services per conception are more when low level of nutrition is practiced (Kaur and Arora, 1982).

Feed restriction may affect the central mechanisms controlling LH releasing factor. Though the synthesis of LH releasing hormone (GnRH) is not altered but its release is hampered which in turn effects LH release from anterior pituitary. N-methy1-D-aspartase activates the release of GnRH from the hypothalamus (Ebling *et al*, 1990), which is inhibited as a result of under nutrition. Certain nutritional signals such as amino acids and non-esterified fatty acids act as nutritional signals influencing GnRH-LH axis (Howard *et al.* 1987). It is further reported that tyrosine and insulin enhance the pulsatile release of LH (Schillo, 1992). Insulin binds with insulin specific receptors in the acruate nucleus and median eminence areas of brain and control GnRH secretion (Cox *et al.*, 1990). The theory behind the action of tyrosine is in the increased synthesis of catecholamine neurotransmitter in the central nervous system (During *et al*, 1989). A recently discovered peptide neuropeptide-Y (NPY) has been shown to provide a link between the control of feed intake and secretion of GnRH. Higher levels of NPY in specific hypothalamic regions such as the paraventricular and acruate nuclei, is inhibitory to release of LH (Malven *et al*, 1990).

Not only protein and energy deficiencies are affecting the reproductive system but low levels of certain minerals and vitamins are also the causative factors. Minerals like copper, cobalt, zinc, manganese, sodium and vitemins of the type vitamin A and E are responsible for reproductive failures. Thus balancing of the diets is not only necessary for production traits but also for proper functioning of reproductive system. Under-feeding is rather more expensive as compared to optimum feeding where the animals mature early because well-fed calves show better growth rate. Maturity and puberty is more a function of early live weight gain than age.

BIOTECHNOLOGY AND FEED TECHNOLOGY

Biotechnology is a rapidly growing integrated **multi-disciplinary** subject of creating and commercializing newer biologically synthesized agents using genetic engineering and recombinant DNA technologies or even mutations which are proving to have a profound beneficial impact in a number of areas. In the recent past, biotechnologists are engaged in discussing and compiling information on various aspects of biotechnology in feed industry. The technology is concerned about the use of feed additives such as enzymes and probiotics (bacteria and yeast) which are expected to increase feed utilization and increase animal performance in terms of production traits such as milk, meat, eggs and wool etc. Yeast culture and lactic acid bacteria in combined form or even given on single item basis have proved beneficial in ruminants, non-ruminants, fish and rabbits. The latter two are proving alternative and safer sources of foods of animal origin as protective proteins for human consumption. Similarly, biotechnological techniques have shown an effect on mineral metabolism, feed storage and even waste handling. Studies are being conducted to develop a genetic blocking agent which retards cow's production of lactose, and in turn produces a thick creamy milk which could be obtained by milking cows only once a day. The impact of such a strategy would be on reducing the cost of transport and later its processing in the factory. Lactose creates osmotic pressure inside the udder and sucks in water from the tissues (blood).

As early as in 1907, Metchnikoff postulated a theory that the pathogenic effects of certain bacteria could be overcome in the gastro- intestinal tract by giving certain feed additives framed from beneficial microbes. To this theory, it is attributed that yoghurt and curd which are fermented milk by Lactobacillus, are typical examples. Silage, a fermented product from green fodder by *Lactobacillus plantarum*, has been fed for ages without knowing much of the usefulness of this species of organism, except for that this is the best way to preserve the nutritive value of green fodder. It is well known now that *Escherichia coli* which is an enteropathogenic organism and has wider prevalence in man and animals, can be competitively inhibited from mitosis by Lacto bacillus (Sadine, 1972). Thus, this process helps to control the microbial balance in the gastrointestinal tract. Certain organic acids such as lactic acid and H_2O_2 produced by these bacteria alter the pH, at which pathogenic organisms fail to survive (Shahani *et al*, 1977)

Feasibility of Coprinus fungal treatment of straws has been well tested for their nutritive value but some how or the other, the technique has not percolated into the industry. Certain other fungi such as *Trichoderma viride* which are out standing in the production of cellulases, need to be tested for their establishment and for better rumen microbial action in practical animal production systems.

Higher amount of energy release from fodders and later its utilization in terms of production is one area under animal nutrition which needs attention. The following technologies are required to be studied :

- For greater release of energy from fodders, there is a need to improve rumen fermentation pattern. A particular organism is required to be identified and through genetic engineering and transformation, it is required to be propagated in the rumen for its establishment.

- Accelerated rate of cellulolytic activity can be achieved through certain rumen microbes which would liberate more cellulase, hemicellulase and ligninases. Genes for all these are required to be isolated and these can be inserted into a host microorganism for gene cloning. Particularly anaerobic bacteria can be engineered for this purpose for *in situ* rumen digestion.
- Commercial enzyme mixes are being used in rations to release more energy from cellulose, hemicellulose, etc. These enzymes are fractionated and purified from cartain fungi. Possibility of using cartain premixes for cows and buffaloes for higher release of energy in the rumen, as a result of which more acetic acid would be liberated, to be used later after absorption by different tissues of the body including mammary gland.
- Another approach would be to accelerate greater conversion of propionic acid into glucose in liver so that more glucose is available for circulation in blood. In turn the mammary gland is likely to synthesize sufficient lactose. One of the techniques would be to reduce the rate of methanogenesis through the use of iso-acids.

Feeding of bacterial cultures are the examples which are still under evaluation. These may help to synthesize acetic acid at a rate higher than normal, as a source of energy, to stimulate milk production.

MINERAL NUTRITION

With intensive cultivation in many geographical zones, certain soils have shown depletion of some minerals with consequent deficiency in plants. Around 20 elements in various macro and micro quantities are a requirement for livestock including rumen microbes. The deficiencies which have been designated now, are of Ca, P, Mg, Zn, Cu, Co, I and S. As a result, subclinical symptoms are shown or with some showing frank clinical syndromes. Mineral deficiencies may or may not harm the growth or yield of crops but animals consuming such crops are liable to be affected if the levels are not sufficient to meet their requirement. On the other hand, problems of the Se and F toxicity are also on record in livestock. Certain feeds rich in cxalic and phytic acids indirectly induce certain deficiencies because of low mineral absoption rates. Thus, it is necessary to evolve formulations of mineral mixtures, areawise, for their best suitability in different feeding systems. Certain non-leguminous plants accumulate silica in the form of SiO_2 even upto 13 percent; this can be an important factor in depressing digestibility as in rice straw and other roughages. Excess tannic acid in certain feed ingredients has been found to increase the requirement of calcium for milk production.

In short, it is all the more essential to balance properly the mineral requirements of livestock with agro-industrial byproducts which are containing some antimetabolite otherwise optimum production potential may not be obtained.

Chelated Minerals : Minerals can be made to chelate with chelating agents either with amino acids such as lysine, cysteine, histidine or proteins e.g. case- in or even peptides. Such mineral chelates have better bioavailabiltiy because absorption rate is superior to the extent of 300-500 percent than inorganic salts. Metal ions form an organic ligand with chelating agents which donate electrons. Such examples do exist under natural conditions when metal ions from soils form complexes with organic compounds during plant growth. Phytic acid, oxalic acid and citric acid are typical plant organic complexes which can chelate minerals. Haemoglobin having a porphyrin nucleus binds one iron atom per mole. Cytochromes and vitamin B_{12} are other examples. Many enzymes chelate metals for their optimum activity. Metals are released from these chelated agents at different pH in the gastro- intestinal tract. Commercially, Zn-methionine, Cu-caseinate, Fe-caseinate are the preparations available in the market in certain countries, because casein is considered to be a good ion carrier for Ca, Cu,Fe, Zn and P(Akira and Tekato, 1965)

NUTRITION AND INFECTIONS

Another vital field of research is on certain nutrients which are protective against infection. They indirectly help in increased production. Tocopherols and ascorbic acid along with glutathione (a tripeptide) are known as reactive oxygen species (ROS). They activate xanthine oxidase to suppress the formation of superoxides (O_2^{-}), an action necessary to prevent cellular damage. All of these, when deficient, increase PCO_2 and decrease PO_2 in blood, a situation not suitable for normal metabolism. The latter condition is evident during infection as well. The fore-mentioned nutrients are considered as antimicrobial and viracidal. Their addition to feed stuffs as antioxidants prevent their deterioration.

Another pertinent example is that neonatals are always at risk and mortality is quite high. The reason being that they are deprived of certain hormones when not given in adequate quantity from colostrum or milk (Levander, 1997). Lately, certain hormones such as insulin -like growth factor-1, (Burrin 1997) cytokinins such as interleukins and interferon and prolactin in milk have been identified which stimulate immune system. Prolactin particularly influences lymphocyte maturation and their functional ability towards development of immunity.

Human milk contains certain nucleotides which help in immune function and intestinal repair in the digestive tract (Hamosh 1997). Such nucleotides need to be estimated in cow or buffalo milk etc.

ENVIRONMENT

Mankind is particularly concerned about environmental influences of animal husbandry. Tropical climate is one problem as a result of which there is Maillard reaction, a process in which there is browning action of protein, whereas on the other hand lignin forming cellular network is inhibitory to digestion of nutrients. Imbalanced feeding causes more liberation of H_2 which is converted into methane causing more energy loss and leading to green house effect.

All the above mentioned areas of research can be considered as the thrust areas which could be pursued in the next 10-20 years not only to augment production traits but also to reduce the disease incidence and in consquence to lower the mortality rate particularly in neonatals.

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FEEDING STRATEGIES FOR INCREASING MILK PRODUCTION: PERSPECTIVE 2020

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Major transformations have been brought about in restructuring the unorganised sector of dairy industry in India in recent decades due to strides made in milk production and above all dairying has been visualised as a tool for rural development and employment generation. Inspite of shortage of feed and fodder supply to the tune of about 47 percent, animal agriculture is contributing about 26 percent of total value of agricultural sector and 7 percent of GDP as per a recent estimate. This achievement is made by utilizing the locally available low quality feed resources. The breedable female cattle population is expected to increase from about 70 million in 2000 AD to 75 million in 2010 and to about 82 million in 2020 AD. This is based on the compound growth rates per annum in breedable cattle population as 0.84 % and in breedable buffalo population as 1.57 %. Out of these animals, crossbred population at the rate of 15 percent in 2020 as against 10 percent in the year 2000 AD, would be around 15 million. India's vast animal population provides an avenue for further enhancing milk and other animal products viz. meat, skin, hide, wool etc. for boosting the animal agriculture industry provided a visionary approach is applied for augmenting the nutrients from the available feed resources and managing the vast animal population from the view point of health and related aspects.

Animal husbandary has a long tradition in India and it is an integeral part of socio- relegious system. It is impossible to break the traditional approach on the lines being practiced in advanced countries. The only desirable thing can be done to incorporate the scientific interventions in the traditional approch which can act as a catalyst for productivity of animals. Though the scientific technologies have been tailored to the needs of animal owners during last few decades but these have not been able to made a significant dent upon the acceptability among animal owners due to various reasons. Among the reasons for less response, prime one is the lack of scientific attitude of animal owners as they expect the same response from animals as they do get from their crops following scientific technologies. Secondly, the animal husbandary is considered subsidery to agriculture throughout the country. Such constraints are difficult to over come and technological intervention in the case of livestock at farmers level is slow. The major expectations are from industry particularly from feed industry and animal product processing industry which can play the pivotal role in transforming the productivity of our livestock.

The paper briefly details the scenario of feed supply, identifies issues and prespectives, and suggests the programmes for enhancing the productivity, so that nation can meet the challanges posed to the livestock sector. The critical analysis of whole scenario from the view point of livestock feeding suggest the following points:

STRENGTHS

Enhanced milk production inspite of shortage of feed resources, thereby increasing the availability of animal protein to consumers
Improved transportation and communication facilities
Increased availability of indigenously manufactured equipments for processing the feeds and animal products
Vast natural resources including animal breeds well adapted to the local environment and feeding practices
Socio-relegious and agriculture system
Vast pool of trained personnel in the field of research, development, health, and extension
Participation of women in animal management.

WEAKNESSES

* Tropical climatic conditions
* Lack of awareness about balanced feeding
* Seasonal fluctuations in availability of feeds reflecting in milk production pattern
* Regional imbalances in livestock population and feed resources
* Low productivity of cattle and arable land
* Lack of coordination between research, feed industry, and extension workers
* Absence of data records which is essential for preparing development programme
* Lack of infrastructure to control the diseases among animals
* Lack of awareness/facilities about the processing of crop residues

THREATS

Increasing use of crop residues in other industries
Increasing popularity of mechanised harvesting of crops resulting in sizable loss of crop residues
Invariably poor quality of compounded cattle feed
Export of good quality oil cakes and meals
Less availability of molasses to the feed industry
Indiscriminate use of crossbreeding programme
Recurring natural calamaties viz. draught, flood etc.

OPPORTUNITIES

- Increasing demand for milk and other animal products
- Employment generation through organised collection and processing of non-conventional feed resources into compounded/complete feeds
- Scope for the utilization of waste from fast growing food processing industry in organised sector in the country
- Availability of animal production technologies for faster development and effective implementation.

India has vast infra structure for dairying which includes livestock, feeds and facilities for their processing , research and development, health coverage, breeding and extension besides the facilities for processing the milk and othe animal products. If we look about the distribution of livestock population and other infra structure ,regional disparities are evident eg. states viz Haryana, Punjab have good quality animals and comparatively better feed resources than Orissa ,Bihar. It is also a fact that from these states unproductive animals are being pushed to other areas from where these animals finally find their place in to the slaughter house or smuggled illegally. Two major conclusions are apparent:

1. Feed deficiency is a continuing problem
2. Despite regional imbalances in feeds availability and animal population, milk production is gradually increasing reflecting the improved feeding and management system.

STRATEGIES FOR OPTIMUM UTILIZATION OF NON-CONVENTIONAL FEED RESOURCES

Processing of non-conventional feeds : India has a capacity to manufacture about 6 million MT of compounded feed in organised sector and equal quantity in small scale private sector, however, the industry is utilizing 50 percent of its capacity thereby the availability is about 6 million MT compounded feed annually. Currently total feed requirement is about 7.5 million MT for poultry and about 36 million MT for cattle totalling 43.5 million MT. The minimum feed requirement for poultry and cattle by 2020 may be estimated as about 80 million MT. These estimates may be variable but deficiency for feed resources will continue in the comming years. Here it can be stressed that compounded cattle feeds generally contain non conventional feed ingredients which do not have any other utility and have low nutritional value due to the presence of one or other incriminating factor. However, the use of such ingedients in cattle feed provides an avenue to harness the natural wealth to the tune of about Rs. 600 crores and Indian livestock inturn provide nutritious food. Though many non conventional feed ingredients are now being used routinely yet the search for newer feed resources is not over. Efforts are continously being made to search newer feeds and their potential as feed ingredient.

Recently, the wastes from food processing industry,a comparatively new development in India, have opened a new vista for animal feeds as about Rs. 38409 crores are expected to be invested in this industry which may yield sizable quantity of wastes (byproducts) having considerable nutritional value for ruminants and other livestock. However, extra arrangements have to be made for handling and utilization of such byproducts. It is expected that this resource will definitly bridge the gap between supply and demand for the nutrients for livestock.

Collection of feed resources : Byproducts from forests such as oilseeds viz. neem, mahua, karanj, salseed etc. and pods viz. babool are being utilized in the cattle feed as these are having sizable nutrients content. These are collected and processed under unorganised sector, hence attention can not be given for their quality and processing. The technologies for the extraction of their incriminating factors and using these pharmaceuticals in other industry would make these less palatable ingedients more palatable and encourage setting up of other industries. The example of neem extract can be cited in this context as the neem extract is being utilized as natural insecticide and resulting byproduct is useful for livestock. Such oil seeds and tree leaves (abundantly available in forests) can be used after proper supplementation in the form of complete feed, preferably in the form of crop residue based blocks. Such strategy may be useful for providing the jobs, feed to the animals and judicious utilization of natural resources. Such complete feeds will also be helpful to tackle the problems of drought/floods as the densified feeds can be transported, handled and stored conveniently.

Mineral supplementation : Mineral content in feeds and fodders depends upon the mineral status of soil. In general, minerals are not applied to the soil and there is definitly a high pressure on soil due to enhanced agricultural practices resulting in poor supply of minerals through feeds and fodders. Supplementation of minerals do not find any place in traditional system as evident from many nutritional surveys in different pockets of the country. Mineral supplements can be formulated according to the needs of the animals of particular area as excess feeding of minerals may not only be uneconomical but may be deterimental for the health of animals. Such strategy will only be applicable when complete picture of mineral status of soil, plants and animals of different areas are known.

Feeding system : All year round feeding system relevent to a particular area may be developed based on locally available feed resources. Such system may include the feed resources to be utilized effectively and to make available feed resources through out the year adopting suitable conservation methodologies.In this regard, traditional feeding system should not be ignored and continous supply of feeds must be ensured to meet the production requirements of animals. Such strategy can define the critical constraints at paticular season for either dietary energy or protein to enable the interventions such as strategic supplementation to the traditional feeding system.

Export of feeds : The oil seed production has witnessed a gradual increase during last several years due to the emphasis from the government policies but the availability of oil cakes to the indigenious animals have not registered any improvement because good quality cakes are either being exported or being used in ever growing poultry industry. Possibly the planners do not expect the same return from our livestock in terms of milk, meat, and eggs as they are getting by exporting the oil cakes. For example the export of groundnut extraction only witnessed a growth of about 33.9 per cent to 3.50 lakh tonnes valued at Rs. 250 crores in 1996-97. A phenomenal rise in value realisation could be attributed to a shortfall in the international availability of proteins for animal feed and consequently rise in their values world wide. Indian livestock would possibly be not able to give the same return in money after utilizing the commodity locally but it seems to be a temporary phase and when our livestock are in need of protein rich feeds especially those having higher productivity it is not advisable to export the commodity. Best strategy would be to export the value added products such as compounded feed/complete feed .

Male buffalo calves for meat production : Scientific and technological advances have changed the traditional food habits in general and productive aspects in particular among farmers. Extensive adoption of hybrid seeds and crossbred animals have given new dimensions to the crop production and animal productivity in certain areas, with the result farmers are increasingly understanding the changing equations of capital investment and productivity. Recently , the potential of male buffalo calves for meat production has been realised and it is envisaged that this resource ,which is still being not utilized, can prove a mean for the income for farmers and the nation. According to an estimate about 10 million male buffalo calves are born annually in the country and having high mortality due to negligence for their feeding and managenent. Results at National Dairy Research Institute , Karnal have shown that a growth rate of about 700 to 1000 g can be achieved in non descript male buffalo calves if provided proper nutrition and such calves can provide good quality meat. The rearing of male buffalo calves,against whose slaughter there is no religious taboo, in an organised farms can prove an asset to the farmers.

Health Coverage : Internal and external parasitic infestation is very common in Indian livestock which further aggrevate the nutritional deficiency thereby affecting the animal productivity. Parasites reduce the efficiency of energy utilization for fat and protein deposition and causes the large loss of productivity. It is apparant that parasitism often depletes body proteins, particularly those circulating in plasma. In addition anaemia due to blood loss is the most obvious symptom. Since digestion and/or absorption of nutrients affected adversely,,which results higher amount of proteinaceous material to move to the caecum, thus decreasing the availability of amino acids relative to energy,ultimately feed intake and its fermentation in rumen affected adversely. To combat the menace of parasites suitable measures must be taken . Such measures will definitely yield dividends in the form of enhanced milk and growth production among Indian livestock with the existing feed resources.

DEVELOPMENT STRATEGIES FOR INCREASING MILK PRODUCTION

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Although, next to U.S.A. India is the largest milk producer in the world today, however, 69 million MT milk is produced in India by approx. 100 million animals, whereas, 70 million MT milk is produced in the U.S.A by just 9.2 million animals. This indicates the vast difference in productivity of animals between developed countries and India. This is primarily due to low milk production potential of our livestock, inadequate feed and fodder resources, recurring epidemics and socio-cultural compulsions, limiting the scope of the dairy industry in our country.

Let us recall that the average income from the sale of milk alone in rural areas was approx. 22.50 per cent (national average) in 1992, and the livestock sector tops in rural employment with annual growth rate of 4.5 per cent against 1.75 for all sectors and 1.1 for agriculture. However, due to ever increasing human population, land availability for supporting livestock production remains the same inspite of relentless growth of cattle population.

In view of the above, it is essential that the national strategies evolved are able to improve the livestock productivity per unit and increase the income of rural masses from sale of milk which being one of the main sources of their livlihood. Besides planned breed development of cattle and buffaloes and animal health practices, it is imperative that existing feed resources are judiciously utilised in the country which can help improving economics of milk production. For example, crop residues and grasses are burnt in some parts of the country while they are selling at approx. Rs. 4/- per kg in some of the states. Similarly, there is no control over the quality of cattle feed and mineral mixtures, being fed to livestock. Also, there is no widespread use of some of the proven technologies in our country which can be easily propagated using local resources. To mention a few, feed supplements, straw treatment, bypass protein, bypass fat, compaction and storage of crop residues and grasses, quality cattle feed production etc., are some of the technologies which have been briefly described in this paper.

JUDICIOUS USE OF CROP RESIDUES AND GRASSES

Traditionally, particular type of crop residues are fed to livestock in a region while rest of them are destroyed. For example, paddy straw is preferred in the Western region for feeding while wheat straw is burnt. However, in North it is wheat straw whichn is fed to livestock while most of the paddy straw is burnt. On the other hand, there is serious shortage of dry fodder in some of the States like in

South and Eastern parts of the country where dry fodder is sold at approx. Rs. 3.00 to 4.00 per kg. The surplus dry fodder from these states including forest by-products, can be collected, enriched with urea, molasses and minerals, baled and transported to deficit areas.

By densification process, developed at Indian Grassland Fodder Research Institute, Jhansi, stack volume of straws and grasses can be reduced by five times, i.e. from 14.0 m^3/MT to 2.7 m^3/MT. Systematic studies were taken up at this institute in collaboration with the NDDB, Anand wherein urea (0.5, 1.0, 1.5%), molasses (5,10,15%) and minerals (0.5, 1.0, 1.5%) were incorporated before subjecting the material to densification. Storage studies conducted upto a period of one year showed that these supplements significantly improved the nutritive value of straw/grasses, without development of aflatoxins.

As a result of densification, transport cost can be reduced by approx. 5 times compared to loose roughages as only 2 MT straw/ grasses can be transported by loose method and approx. 6 to 7 MT by baling. This can also reduce storage space and increase shelf life, besides improving the nutritive value.

QUALITY OF CATTLE FEED FED TO MILCH ANIMALS

Inferior quality cattle feeds available across the country are causing irrepairable damage to livestock production. In absence of a law governing the quality of animal feeds in the market, there is no check on the production of such types of compounded cattle feeds. Over the years there has been constant increase in the price of cattle feed raw materials. Contrary to this, compounded cattle feed price has not increased proportionately with increase in price of raw materials. Obviously, several feed manufacturers are compromising on the quality, which is a never ending process.

The NDDB's Biotechnology laboratory at Anand collected feed samples from various regions of the country through its field staff. All these compounded cattle feeds are supposed to conform to BIS-type-II specifications, however, as can be seen from the average chemical composition (figure 1), quality of these feeds has significantly deteriorated over the years. There is hardly any production of quality feed in the country which can support milk production in high yielding animals.

There should be a feed law in the country specifying the quality of animal feeds to be produced, below which compounded cattle feed should not be allowed to be produced and composition of cattle feed should be declared on the bag. Feed manufactures should take up production of quality feeds for meeting requirements of high producing animals. Even Government should restrict export of quality feed ingredients so that they are indigenously available at a reasonable price for production of superior cattle feed.

AVERAGE COMPOSITION OF CATTLE FEEDS FROM DIFFERENT REGIONS OF THE COUNTRY

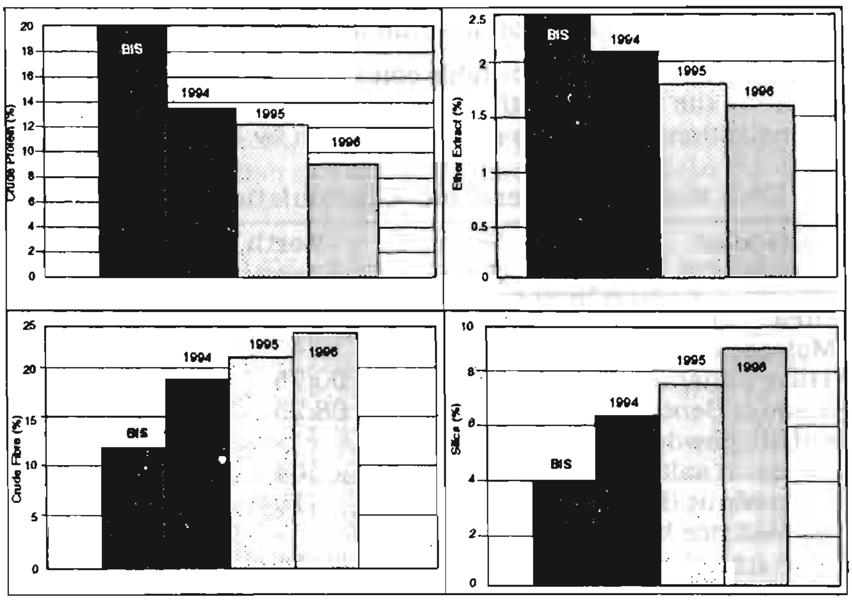

Fig. 1

FEED SUPPLEMENTS AND STRAW TREATMENT FOR IMPROVING NUTRITIVE VALUE OF BASAL DIET

Crop residues form the bulk of basal diet of livestock in our country. These crop residues have practically no protein, low energy and minerals and poor digestibility due to ligno-cellulose complex encapsulating the cell content. The nutritive value of such a basal diet can be improved either by way of using strategic feed supplements or by treating the crop residues with urea (ammonia), which increases the nitrogen value of crop residues as well as increases digestibility.

Use of urea molasses mineral block (UMMB) feed supplement is practiced in several developing countries. UMMB feed supplement comprises of urea, molasses, minerals, brans/cakes, common salt, phosphate supplements etc., which provide optimum quantities of nitrogen, energy and minerals for the growth of microflora in the rumen which in turn help in the efficient fermentation of crop residues. Ruminant animals get more microbial protein and minerals by way of enhanced microbial synthesis of these nutrients, as well as more energy through increased DM intake from crop residues. Such feed supplements are economical and help in improving production and reproduction of ruminant animals. The Biotechnology laboratory of NDDB, Anand has developed plant for manufacturing UMMB lick by 'cold process'. Formulation and sequence of adding ingredients for various regions and climatic conditions have also been standardised[1]. Some of these formulations have been given in Table - 1. Various workers have shown that

UMMB supplementation in diet helps improving the feed intake, rumen fermentation, growth and milk production in ruminant animals[2-5].

Similarly, under the favourable conditions, urea (ammonia) treatment can be practiced by the farmers at the time of storing the straws/crop residues. For this, demonstrations to farmers need to be given by the extension workers.

Table 1 Urea molasses mineral block formulation for difference regions

Particular	West Zone	North Zone	South Zone	East Zone
Urea	10	10	06	06
Molasses	45	45	45	45
Trace mineral	00.75	00.75	00.75	00.75
Sodium Bentonite	08.25	08.25	-	-
Calcite powder	-	-	06.25	06.25
Common salt	-	04	04	04
Groundnut (Ext)	-	10	-	-
Deoiled rice bran	14	-	12	12
RPF	14	14	10	10
Calcium Oxide	04	04	04	04
Mangnasium Oxide	-	-	02	02
Phosphoric acid	02	02	-	-
Guar gum	02	02	-	-
D.A.P	-	-	10	10

(Source : NDDB, 1997)

BYPASS NUTRIENT TECHNOLOGY

Feed nutrients ingested by the animals are selectively fermented in the rumen by microflora. Fermentation end-products are partially used by microflora for building their own body blocks and partially utilised by the host animal for meeting their requirements. Degradation of nutrients in the rumen, which are highly digestible in the abomasum and small intestine, beyond meeting microbial requirements, leads to their under utilization. If such feed nutrients are allowed to degrade in the rumen to a limited extent, it is possible to increase the net nutrient availability to host animal for milk production and growth. Degradation of feed nutrients in the rumen can be controlled either by selecting feeds having low degradability in the rumen or by chemical treatment. Controlled degradation of nutrients in the rumen for improving nutrient availability is also termed as the bypass nutrient technology. Bypass starch, protein and fat technologies are described here in brief.

Bypass starch : Starch is hydrolysed to glucose in the rumen by the action of amylase enzyme. Glucose is then converted to various volatile fatty acids via lactic acid. Propionic acid is again converted to glucose through gluconeogenesis to meet glucose requirements of animals for generation of ATP, NADP ($+H^+$) and for lactose synthesis in mammary gland. Instead of this, if starch is enzymatically digested in the abomasum then more glucose can be made available to the animal. This has been shown by treating the starch with sodium hexametaphosphate[6] at alkaline pH. However, the cost of treatment seems to be high in terms of economic benefits. At the moment, it is felt that the natural sources of bypass starch, such as corn grain, rice polish etc. should be used, especially in the ration of high yielding animals.

Table 2. CP, RDP and UDP values of some commonly available protein sources at rumen outflow rate of 0.05/h

Protein source	CP (%)	RDP (%)	UDP (%)	UDP as % of total CP	Reference
G.N. cake (Extracted)	40	36	4	10	
Cotton seed cake	40	22	18	45	
Wheat bran	18	13	5	28	13
Deoiled rice bran	16	10	6	38	
G.N. cake	42	39	3	7	
Til cake	40	29	11	28	
Mustard cake	38	33	5	13	14
Soyabean meal	45	39	6	13	
G.N. cake	39	18	21	54	
Linseed cake	32	13	19	59	15
G.N. cake	45	30	15	33	
Gingelly cake	35	29	6	17	16
Ruber seed cake	28	19	9	32	
Coconut cake	28	6	22	79	
G.N. cake	47	9	38	81	
G.N. cake (Extracted)	49	15	34	69	
Cottonseed cake	40	7	33	83	17
Safflower cake	22	13	9	41	
Tobacco seed cake	29	12	17	59	
Silk cotton seed cake	33	26	7	21	
Niger seed cake	35	11	24	69	
Sunflower seed cake	35	16	19	54	
Cotton seed meal	24	12	12	50 (43)	
G.N. cake	31	24	6	23 (19)	
Linseed cake	27	11	16	59 (54)	18
Mustard cake	43	36	7	16 (13)	
Soyabean meal	50	19	31	62 (57)	

( ) DUP : digestible undegraded protein, - UDP corrected for ADF-N

Bypass protein : Ruminal microbes don't provide adequate protein for meeting the nutrient requirement of the mammary gland for milk production. Major portion of the good quality dietary protein must escape ruminal degradation and pass to abomasum and small intestine to supply sufficient amounts of amino acids. Therefore, dietary proteins should be fractioned into rumen degradable protein (RDP) and rumen undegradable protein (UDP). Feed should be formulated in such a way that it is able to provide 60 per cent UDP of the total CP in the diet which helped significantly in improving milk production in cows fed on crop residue based diet[7].

Protein sources differ in their remen degradability. Some protein sources contain naturally available rumen bypass protein viz. corn gluten meal, cotton seed meal, toasted guar meal, toasted soyabean meal etc which can be used in bypass protein feeds. Otherwise, protein meals having high ruminal protein degradability can be subjected to heat or chemical (formaldehyde) treatment. Different protein meals require different degree of heat or chemical treatment for achieving appropriate level of UDP. If a common treatment is applied to all the protein meals, some of them may only be protected to a very limited degree while some of them may get over-protected[8]. Degradability of some of Indian meals/cakes is given in Table-2.

By using bypass protein feed formulation, quality feed resources which are available in limited quantities can be judiciously utilised for feeding high yielding animals as it is shown to be more effective in animals fed crop residues or where there is energy deficiency in the diet[8]. Such situations exist in all the developing countries, including India where use of bypass protein feed technology can be fully exploited for augmenting milk production.

Bypass fat : Energy density of ration in lactating cows is low in developing countries. After calving when milk production tends to increase, feed intake is low due to hormonal changes taking place in the body. Animals, especially high yielders, loose body weight heavily which affects production and reproduction.

EFFECT OF FEEDING BYPASS FAT ON DAILY MILK PRODUCTION IN HF COWS

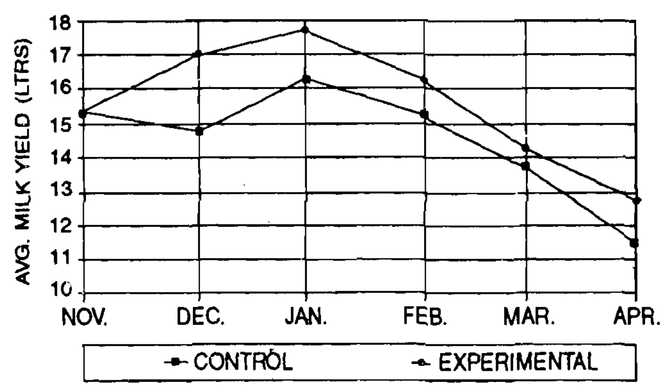

Fig. 2

High level of fat or grains in the diet can adversely affect rumen fermentation[9], thereby, affecting fibre digestibility. It is reported that bypass fat, inert in the rumen, could be used for increasing energy density of ration and improving milk production and reproduction[10].

Acid oil and free fatty acids are the by-products of oil refining process, available at approx. one third the price of edible oil and contains approx. 95 per cent fatty matter. Bypass fat produced from acid oils was fed to lactating HF cows @ 500 g per animal per day, in addition to basal ration similar in control and experimental groups. Milk and fat production increased significantly (Figure-2), especially during first quarter of lactation[11]. If acid oils and free fatty acids are converted to calcium salts and fed to lactating animals having high milk production potential, fat and milk production can be significantly and economically improved. Since animals fed bypass fat loose less body weight, their reproduction efficiency also improves and intercalving period is reduced. After extensive research and field trials with bypass fat feeding, the National Dairy Development Board, Anand is likely to set up plants for manufacturing bypass fat, which could be made available to farmers in different regions of the country.

MINERAL SUPPLEMENTATION

Domestic livestock needs scientifically balanced diets for improved economical efficiency. This efficiency depends upon the adequate quantity and quality of nutrients, of which mineral elements is one of the most important components. It is well recognised that minerals play important role in metabolism and are essential dietary requirement. The role of minerals is well estabilised for various metabolic functions. Various mineral elements function synergistically in body tissue. Therefore, deficiency or excess of one element is likely to affect the functioning of others because of the associated relationship. Typical examples are there of Ca, P, and Mg in bone formation and Fe, Cu and Co in RBC synthesis.

In formulating mineral mixtures for proper utilisation in the tissue, it is necessary to consider their bio-availability. Most mineral mixtures available in the market are not formulated based on bio-availability and the regional requirements. Further, the rate at which they are incorporated in compounded cattle feed is not on scientific lines, ranging from nil to 1.0 per cent. There are reports of excessive intake of certain minerals, whereas, other are deficient.

Like cattle feed, there is no regulatary act for mineral mixtures as well. In a particular zone, several types of mineral mixtures are being sold which vary widely in their mineral composition. Not only that, many of them are using industrial by-products or rock phosphate which contain high levels of fluorine and bioavailability of macro elements such as calcium and phosphorus is always doubtful from such sources.

In view of the vital role played by the minerals in metabolic functions including milk production and reproduction, appropriate sources of mineral salts, at appropriate levels should be incorporated in mineral mixture formulation. Mineral mixture should be fed at optimum level to lactating animals for improving their production efficiency.

Table 3. Range and mean of various mineral elements in feeds and fodders (DM basis)

Feed/Elements	Ca (%)	P (%)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Compoun cattle feed	0.81-1.85 (1.08)	0.82-1.11 (0.93)	25.70-48.60 (36.46)	33.01-70.46 (58.27)	66.80-131.90 (97.71)
Bajra straw	0.17-0.58 (0.41)	0.05-0.27 (0.14)	3.30-24.48 (10.96)	4.90-29.20 (16.92)	33.30-841.0 (51.03)
C.S. cake	0.14-0.40 (0.30)	0.52-0.67 (0.58)	12.10-30.90 (23.01)	40.81-59.50 (49.44)	30.50-59.36 (46.66)
Hybrid napier	0.490.75 (0.64)	0.18-0.51 (0.29)	7.10-22.60 (16.23)	10.60-30.60 (21.81)	77.30-143.90 (111.20)
Lucerne green	1.24-2.03 (1.74)	0.16-0.58 (0.33)	14.60-39.10 (28.57)	23.10-45.43 (35.55)	56.60-129.90 (84.09)
Jowar green	0.02-0.59 (0.20)	0.09-0.39 (0.23)	3.21-22.25 (9.39)	10.80-38.53 (25.91)	23.20-77.34 (37.19)
Jowar straw	0.19-0.58 (0.38)	0.01-0.31 (0.14)	3.21-22.25 (7.53)	10.80-38.53 (14.69)	23.20-77.34 (64.82)
Wheat straw	0.10-0.37 (0.19)	0.01-0.15 (0.07)	1.40-6.44 (3.48)	1.50-9.90 (5.99)	34.70-59.27 (42.48)

(Source : NDDB, 1997)

It is also essential that various research institutions in different regions of the country take up research work to establish regional requirements of minerals by the animals so that mineral mixtures could be manufactured region-wise. A survey work conducted in Northern Gujarat in this regard indicated that while magnesium, iron and cobalt and sufficient in the diet of lactating animals, there is deficiency of zinc, copper and manganese. In several situations there was deficiency of calcium and phosphorus. Several cases of phosphorus deficiency were reported from the field which were corrected by supplementing calcium and phosphorus. Vast variations in mineral contents of the same feed material collected from various sources was observed (Table 3)[12].

CARE AND MANAGEMENT OF FIELD CALVES

It is well known that the mortality rate of calves, especially buffalo calves, is very high under field conditions. It is mainly due to their poor upkeep and under feeding. Proper feeding and management can help attaining puberty between 18 to 22 months in buffalo calves under field conditions, although it is well established only for crossbred calves.

In the field progeny testing programme undertaken by the Mehsana District Co-operative Milk Producers' Union Ltd., Mehsana, female calves of high yielding buffaloes were identified and provided package practices at subsidised rate, including good quality balanced cattle feed. These inputs were provided on fortnight basis. After every fortnight, these calves were assessed for growth rate. Next consignment of inputs was released only when the growth rate was found to be satisfactory. Mortality rate was significantly reduced, age at puberty was reduced. Even the milk yield in first and second lactations improved. Sucha programme helped building large herd of high yielding buffaloes in the milk shed areas. Such programmes should also be replicated in other parts of country.

In view of the above, it appears that if the existing feed recourses are judiciously utilised, coupled with strict control on the quality of cattle feed and mineral mixtures and high quality feeds as supplements are given to high yielding animals, productivity of milch animals can be significantly enhanced.

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HERBAL MEDICINES ; AN UNTAPPED TREASURE IN POULTRY PRODUCTION

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The new catchword the world over is herbal therapy or herbal treatment, as synthetic drugs and chemicals have their inherent disadvantages such as high cost of production, toxicity from prolonged usage, contraindicators, development of resistance, environmental and health hazards besides Government policies and controls. The herbal product makes for a safer alternative due to its suitability and preference, lower cost of production, being environment friendly by nature, reduced risks of toxicity and health hazards and most important of all, it is a natural product.

The Indian systems of medicine such as Ayurveda, Unani, Pancha Karma and Siddha have been persisted with this country since history has been recorded and is still being practiced due to their affectivity in curing illness and for general well being and health. Although the principles and practices, doctrines and approach of these systems for therapeutic usage and treatment vary vastly, but the main ingredients used are naturally occurring products such as minerals, animal and plant products with plant materials constituting more than 90% of the formulations. India boasts of about 7500 species of medicinal herbs out of which, more than 700 herbs are the mainstay in Ayurvedic formulations.

The origin of herbal medicines has been attributed to our ancestors who had acquired the knowledge of plants, mainly by trial and error to determine which plants had food value and which were poisonous. Thus, the healing powers of certain herbs and roots were discovered and the, information was passed down from generation to generation, added upon by fresh discoveries, not forgotton and later recorded.

THE INDIAN HERBAL MARKET SCENARIO

Herbal medicines in India are still prepared to a larger extent from crude plant materials such as roots, rhizomes, tubers, stems, leaves, flowers, fruits, barks and seeds, in which, besides harvesting and drying very little further processing takes place which renders it very cost-effective. Pioneers in herbal formulations in India who have entered the Veterinary medicine market include M/s Indian Herbs, M/s Dabur Ayurvet Ltd., M/s Himalayan Drug Co., M/s TTK Pharma etc., whose complete range of poultry medinces are herbal formulations. Due to high efficacy and commercial value, other pharmaceutical giants in the veterinary field have also diversified into producing herbal formulations. Due to this expanding market and fresh thrust into herbal formulations, high-tech laboratories have seen set up for chemical analysis, in-house clinical trials, quality control research and development besides selective extraction of the active ingredients, derivatives and solvents from the crude plant material to ensure better efficacy.

The major chunk of commercial herbal formulations concentrate mainly in four thrust areas, namely:

a) Formulations to counteract stress and act as immunomodulators.
b) Formulations for respiratory afflictions.
c) Liver tonic.
d) Growth promoters for better health and productivity.

PROPERTIES OF COMMONLY USED HERBS IN POULTY

1. **Azadirachta indica (Neem):** Neem extracts, extensively used in agricultural farms as insecticides have opened a new avenue of neem as disinfectant in poultry farm due to its antimicrobial properties. Neem contains several active ingredients which chemically resemble steroidal compounds, which include cortisone, birth control pills and many valuable pharmaceuticals and belong to a general class of natural products called triterpenes, more specifically, limnoids. These compounds are Nimbin, Azadirachtol, Azadirachnol, Azadirone, Azadirachtin, Salannolides etc. Azadirachtin is a well known compound and active ingredient in the neem extract (NRC, 1992).

Neem extract had suppressed the growth of pathogenic bacteria including *Staphylococcus aureus*, Mycobacteria, *Salmonella paratyphi* and *Klebsiella pneumoniae* and also been used as antimalarial febrifuge, anthelmentic, vermifuge, antiseptic, antimicrobial and as an external applicant against various skin disorders (cited by Koul *et al.*, 1990). Neem extract inhibited Ranikhet disease virus both *in vitro* and *in vivo* (cited by Koul *et al.*, 1990), Herpes virus (NRC, 1992) and Pox virus (Rai and Sethi, 1972).

2. **Boerhavia diffusa (Spreading Hogweed):** The active ingredients present in this plant are alkaloids, myristic and oxalic acids which reduce SGPT and SGOT levels, increase liver ATPase activity and the drug is of choice for jaundice and ascites. Besides, the plant also has stomachic, spasmolytic, anti-inflammatory and antiviral properties.

3. **Eclipta alba (Bhringaraj):** It is considered the best Ayurvedic herb for the treatment of liver cirrhosis and infective hepatitis. Trials have shown a cytoprotective effect for the hepatocytes against phallidin which is the strongest known hepatotoxin. This antihepatotoxic effect is attributed to apigenin and wedelolactone which are the main phytochemical constitutents.

4. **Inchnocorpus furtiscens (Black creeper):** The active ingredient contained in the stem of this plant are triterpene glucosides which have strong delulscent, antibillious and antiviral properties.

5. **Ocimum sanctum (Tulsi):** Its main property is as an immunomodulator and acts at various levels in the immune mechanism by increasing IgE antibody titre levels, release of mediators of hypersensitivity reactions. It is also a very effective antistress medicine especially to counteract stress related to gastric ulcers and hypertension.

6. Phyllanthus niruri (Niruri): The plant extract consists of phyllanthin, triacontanel and related compounds having antihepatotoxic activity besides inhibiting various hepatic viruses.

7. Picrorrhiza kurroa (Kuru): The active ingredients in the rhizome are irridoid glycosides which exhibit hepatoprotective and antihepatotoxic activity besides increasing total biliary output.

8. Solanum nigrum (Black Nightshade): The plant extracts consist of alkaloids, glycosides and fatty acids which exhibit both, hepatoprotective as well as antihepatotoxic properties.

9. Terminalia chebula (Black myrobalan): The fruits of this plant contains glycosides, tannins and fatty acids which exhibit carminative, stomachic and astringent properties.

10. Withania somnifera (Ashwagandha): Described in Ayurvedic literature as the "rejuvenator". It is the herb of choice for immunomodulation and general well being. Modern research models and studies have established its antistress, adaptogenic and immunomodulatory properties.

11. Tinospora cordifolia (Amrita): Immunostimulator, respiratory stimulant, liver protective and anti-stress properties.

12. Mentha arvensis (Field Mint): The leaves of this plant has medicinal properties. Respiratory stimulant, digestive and antibacterial properties.

13. Zinger officinale (Zinger): Respiratory and digestive stimulants.

14. Punica granatum (Pomegranate): Antibacterial, antifungal and deworming agents.

15. Curcuma longa (Turmeric): Anti-inflammatory, liver tonic and antiseptic.

CLINICAL AND FIELD TRIAL REPORTS

Research institutions and scientists have studied the effect of several commercial herbal formulations in poultry within the country for which more than 300 research papers have been published. These studies have revolved around pharmacological and pathological studies, liver and blood chemistry, immunology, biological trials etc., some of which have been discussed below.

Biological trials of herbal formulations used as growth promoters have established beyond doubt the improved overall performance with respect to weight gain, feed efficiency, lowered mortality and also as therapeutic against liver damage due to feed contaminants like aflatoxins, toxicity caused by chemical drugs and in improving digestion (Ramappa *et al.*, 1975; Rao and Reddy, 1986; Devegowda *et al.*, 1990; Devegowda and Aravind, 1996).

In an extensive study, Devegowda *et al.* (1990) used Livol (product of M/s Indian herbs Ltd., India) in broiler diets at three levels: 0.0, 0.25 and 0.5%. The body weights and feed efficiency of the Livol supplemented groups were significanlty superior to the control group (Table 1).

Table 1. Evaluation of Livol classic to counteract the effect of aflatoxins in commercial broilers

Group	Aflatoxin (ppb)	Livol Classic %	Body wt. (kg)	FCR	Mort. %	Total serum protein g/dl
T1	0	0	1601±46.31	2.10±0.008	0	3.43±0.02
T2	0	0.1	1712±26.07	2.00±0.014	0	3.38±0.03
T3	400	0	1019±39.53	2.3±0.035	12.5	2.60±0.01
T4	400	0.1	1055±66.36	2.2±0.011	4.1	3.20±0.08

In a recent study, Devegowda and Aravind (1996) used Livfit (product of M/s Dabur Ayurvet Ltd., India) in broiler diets and reported the beneficial effects with reduced mortality accompanied by significant improvement in body weight and feed efficiency. However, the benefits in immunomodulation and liver enzyme profile were marginal (Table 2). The results corroborate the findings of Narahari (1995) where significant improvements were recorded in body weights, feed efficiency and livability in broilers fed diets supplemented with 0.2% Livfit.

Table 2. General performance, titres against Newcastle (NDV) and infectious Bursal Disease (IBDV) and liver enzyme profile of broilers fed different levels of LIVFIT

Treatment	Body Wt.	Feed	Mortality	Titres		Liver Enzymes (µg/ml)	
	(g)	Efficiency	(%)	NDV	IBDV	SGOT	SGPT
Control	1523^{a}	2.16^{a}	2.72^{a}	2890^{a}	4525^{a}	45.38^{a}	4.01^{a}
LIVFIT 0.2%	1587^{b}	2.09^{b}	1.51^{b}	3000^{b}	4495^{b}	42.69^{b}	4.68^{b}
LIVFIT 0.40%	1598^{b}	2.09^{b}	1.51^{b}	2925^{ab}	4550^{a}	44.32^{a}	3.96^{a}

Studies on the immunomodulatory action of Zeetress (product of M/s. Indian Herbs Ltd., India) showed adaptogenic and antistress activity besides improving the antibody titre values against Newcastle disease in broilers (Pande and Vijay Kumar, 1994). In an extensive study using the same product, Rao *et al.* (1995) evaluated the host cell mediated and humoral results showed a marked increase in rosette forming T-lymphocytes strengthened by significantly severe delayed hypersensitivity reaction in 2-2-4-dinitrochloro benzene skin sensitivity test. Additionally, the nitro blue tetrazolium test showed increased number of formazan positive cells which indicates increased activity of splenic microphages.

The results of these and several other research papers have established beyond doubt the usefullness of herbal formulations in poultry production. With the growing consciousness universally for a leaning towards naturopathy, the demand for herbal medicines has grown considerably, not only in veterinary field but also to a larger extent in the treatment of men.

Grouping of medicinal plants according to biological acitivity

* Liver protective : Turmeric, Kesuri, Garden nightshade, Amrita, Creat
* Digestive stimulant : Turmeric, Zinger, Field mint, Asafoetida, Indian Gooseberry
* Antimicrobial : Neem, Creat, Kesuri, Tulsi, Amrita
* Antistress : Ashwagandha, Tulsi
* Respiratory stimulant : Field mint, Asafoetida, Garden nightshade, Amrita
* Immunostimulator : Indian gooseberry, Amrita, Satamuli, Tulsi
* Antifungal : Neem, Bhumya-malaki
* Anthelmintic : Bael fruit, Asafoetida, Pomegranate

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QUALITY CONTROL OF FEED INGREDIENTS AND COMPOUNDED FEED FOR SUSTAINABLE POULTRY PRODUCTION

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Indian poultry industry has made a significant growth during the last three decades. The scenario of backyard poultry has now been transformed into a fullfledged agribased, self-content industry. Factors such as planned systematic research, strategies for development, application of modern technological tools in poultry breeding, nutrition, disease diagnosis and health cover, managemental practices and overall the financial input through various agencies and NABARD contributed significantly for the present day egg and broiler development (Table 1, 2 and 3) in the country. Projection of egg and meat for turn of the century is very high targeting around 62,000 million eggs and 900 million broilers in 2000 AD. Such vast expansion would require huge infrastructure facilities to sustain the growth of the industry. Needless to emphasis that demand for feed alone would increase to 10 to 11 million tonnes.

Table1. Progress of poultry production

Particulars	Year		
	1961	1971	1995
Layer population (million)	35	53	159*
Broiler population (million)	-	4	330
Total egg production (million)	2340	5340	28130
Per capita availablity of egg (head/year)	6	9.8	30
Per capita availablity of meat (g)	150	155	566
Value of poultry products (Rs. in crores)	—	—	7810
Plan expenditure (Rs. in crores)	2.8	11.5	128.0
Human population (million)	439	548	900

Source : Poultry Industry year Book, 1994
* *inclues 70 million desi and 89 million improved layers*

Table 2. Top six egg and poultry meat production countries

Countries	Egg (million)	Meat (Million Tons)
China	13600	4.14
USSR (Erst white)	70740	2.81
USA	70456	12.00
Japan	43000	1.37
Brazil	29100	2.93
India	26075	—

Source : Poultry Industry year Book 1994

Table 3. Top five egg and meat producing states in India

States	Egg (Million No.)	Meat (Million Kg)
Andhra Pradesh	6420	49
Tamil Nadu	3510	12
Maharastra	2850	47
Punjab	1589	24
Haryana	1490	Na

Source : Poultry Industry year Book 1994

Feed represents about 70 percent of the total production cost. The feed cost is influenced by price of raw-materials (feed ingredients and additives), agricultural production, climate and weather, Government policies and global economic conditions and role of internal traders and their policies inturn influence raw-material price. Unfortunately, either poultry farmers or the feed manufacturers have little control or no control over all the above factors. Since the growth of the industry is very fast and if operations are to be sustained successfully, more attention is to be paid to the feed, its production, inclusion of unconventional and new raw materials such as agro-industrial, animal and forest wastes and byproducts. Thus, poultry feed which was once considered simple are getting complex. Now-a-days, a poultry feed formulation includes about 10 to12 ingredients, mineral supplements and other micro-nutrient sources and many feed additives.

In view of the inclusion of number of conventional and unconventional feed ingredients, analysis and quality control procedures in feed manufacturing industry becomes more important. Feed manufacturers, and poultry farmers who prepare feed at farm level, very often observe wide variation in performance of birds eventhough the formulation, proximate composition of feed, physical texture of feed and management remains the same. The major reason for such variations/ fluctuations in production can be attributed to the quality of nutrients present in the feed; which inturn indicates the inclusion of poor quality feed ingredients.

The major nutrient composition of poultry feed/feed ingredients are carbohydrates, proteins, fats, minerals, vitamins. Feed additives are added as per the need and requirements of the flock. Utilisation of these nutrients in the system depends on the digestibility of nutrients and their bioavailability for metabolism. Therefore, while formulating a balanced and economical ration one has to be careful in identifying and selecting the feed ingredient giving due importance of the nutrient bio-availability and to the presence of antinutritional and toxic factors. Rations formulated for different categories of birds generally contain 16 to 20% crude protein and 2500 to 3000/3200 ME Kcal/kg. It is evident that major expense in formulating rations is the cost of meeting energy and protein needs which may be about 80 to 90% (cereals about 50%, vegetable protein source 20 to 30%, animal protein source 5 to 10%; fats only 2 to 5%. Generally, protein requirement in the ration is met through vegetable and animal protein sources. In addition diets are also fortified with minerals, vitamins and other necessary additives and supplements. Ingredients supply specific minerals and vitamins and additives though expensive on weight to weight basis, they share a small portion of the total cost of the diet due to lesser quantity of additions.

QUALITY CONTROL AND ANALYSIS

In view of the larger involvement of different types of feed ingredients in feed formulation, it becomes necessary to assess the suitability of the material for the purpose it has been selected. Invariably it becomes problematic to formulate balanced feed when restricted range of widely variable quality raw-materials are available for poultry feed.

How to make quality control effective?

It is very difficult to implement strict quality control measures unless the importance of it is fully realised by the feed manufacturers as well as the farmers. The raw material buyers must ensure that anticipated quality and price is taken into consideration while purchasing the feed ingredients for the feed processing purpose and should examine very carefully before it reaches factory. Management must respond positively to any complaint by the customers regarding the feed quality and should not be afraid to spend more money on different investigations. Proper legislation may be enacted on quality control measure both for raw materials and for the end products. Such legislation would protect the users of the end products of the feed mill and the raw materials available in the market for feed formulation at farm level. In a country like India where there is a shortage of grains for animal feeding and various agro-industrial and animal byproducts are considered for feed formulation. Some official safeguards for the minimum nutritive value and composition of feed and few ingredients are necessary and to be labeled for consumption by particular classes of animals.

VARIOUS ANALYTICAL PROCEDURES

Analysis and quality control of feed ingredients involve physical inspection, microscopic examination, chemical analysis and gross estimation of nutrients and biological evaluation of the nutrients for their nutritional value and bio-availability.

Physical Examination : Physical exmination of the materials forms one of the important phases and basic principles of the quality control programme. Feed ingredients should be free from common and uncommon adulterants. Commonly used cereals such as maize, barley, bajra, jowar, ragi, broken rice and any other millets must be free from

* dust, stones, extraneous materials, insect infestation and fungus growth.

* Moisture content should be less than 12 to 13%. Cereals with high moisture content are more prone to fungus growth. Grains with high insect infestation will be less in weight and will have more number of holes.
* Cereal byproducts must be free from mustry odour, sourness, lumps, dirt, extraneous materials, husk, fungus growth, insect infestations.
* Vegetable protein sources should be free from bitterness, adulterants, rancidity, fungus infestations. The raw-material should have original texture, taste and free from metallic pieces.
* Animals by-products namely fishmeal; meat meal, liver meal and silkworm pupae meal etc., should have characteristic odour and free from any other odour indicative of spoilage.
* Whenever required microscopic examination of the raw-material is to be carried out for identifying the type of adulterants.

Chemical analysis : For many nutrients that are required by animals direct chemical analytical procedures are available by which the potentiality of the ingredient can be indentified. Such information forms the basis of dietary requirements and for practical ration formulations. Commonly used analytical procedures "proximate principles of anlaysis or Weende system of analysis" was developed at Weende research station, in Germany around 1865 by Wilhelm Henneberg and Friedrich Stohmann. Inspite of the fact that the scheme is more than a century old and information obtained through this procedure is limited and sometimes nutritionally insignificant, this system is being widely followed.

Though this method of analysis is still being practiced widely the system has many limitations.

The proximate composition of some of the commonly used feed ingredients and level of inclusion in the diet are given in table 4 and 5, which can be used as guidelines.

Other analytical techniques involved for quantitative estimations : In comparison to proximate analysis, advanced analytical techniques such as Bomb calorimetry, Colorimetry and Spectrophotometry, Chromatography and Near infrared Reflectance spectroscopy are quicker, easier, repeatable and reliable.

Feed evaluation trials : Once the proper techniques have been identified and adopted for analysis it is necessary to set up trials to evaluate the feed for nutritional value and nutrient quality. This can be done *in vivo* or *in vitro* depending upon :- Resources available, Cost involved, Duration and time required for the trial and Desired statistical design.

For poultry, the protein quality and the amino acid composition of the feed ingredients play an important role in formulating balanced diets. Therefore, here only protein quality test has been considered and given.

Protein quality tests : Bio-assay methods are the best known procedures to determine the protein quality of feed ingredient. But, biological tests require more time, require elaborate experimentation and labour consuming. However, few chemical tests which can be carried out in laboratories such as available lysine, total amino acid content, Orange G binding, protein quality index, nitrogen solubility and microbial estimations can rank the feed ingredients close to that of biological tests. Almost all the tests indicate the type of material, processing condition of raw material, improper storage, adulteration etc., All the quality tests will help the nutritionist in ranking the ingredient as per the quality of nutrient while formulating balanced ration.

Table 4. Maximum level of inclusion of feed ingredients in poultry diets

Energy Sources	Level of inclusion (%)	Protein Sources	Level of inclusion (%)
Maize	60	Groundnut meal	40
Wheat	50	Groundnut meal, deoiled	20
Barley	20-40	Soyabean meal	40
Oats	10-20	Sesamum meal	20
Sorghum (dark variety)	10-20	Saflower meal	20
Sorghum (white variety)	25-40	Sunflower meal	20
Pearlmillet	50	Coconut meal	05
Rice	40	Cottonseed meal (degossypolized)	05
Rice bran	10-20	Mustard meal	10
Rice polish	25-40	Maize-gluten feed	15
Rice polish (deoiled)	10-20	Maize-gluten-meal	15
Wheat bran	10-15	Maize-germ-meal	15
Maize bran	10	Niger meal	10
Hominy feed	10	Fish meal	10
Salseed meal (deoiled)	03-05	Fish scrap	05
Molasses	05-10	Fish solubles	30
Animal and Vegetable fat	10	Meat meal	10
Poultry manure meal	10	Meat cum bone meal	05
Tapioca flour	10-20	Blood meal	03
Gram *chuni*	10-15	Poultry byproduct meal	05
		Poultry hatchery byproduct meal	03
		Silkworm-pupaemeal	06
		Feathermeal	02

Table 5 Average chemical composition of some feed ingredients used in poultry feed (On dry matter basis)

Feed	Moisture (%)	CP (%)	EE (%)	CF (%)	Total/Ash (%)	AIA (%)	ME (kcal/kg)
Bajra	10.4	12.7	4.9	2.2	3.0	0.25	2,642
Barley	5.0	12.0	2.8	6.5	5.0	1.00	2,168
Jowar	12.6	10.0	5.0	5.3	3.0	0.34	2.645
Yellow maize	11.0	9.5	4.0	1.9	1.9	0.30	3.309
Rice polish	8.2	13.0	18.0	4.0	3.0	1.50	3,450
Rice bran	9.3	12.0	14.0	12.0	15.0	1.80	2,937
Deoiled rice bran	7.7	14.1	1.7	13.8	17.0	8.30	2.835
Maize gluten meal	9.1	49.9	4.2	2.0	2.9	1.20	2,705
Wheat bran	12.3	14.7	3.8	11.3	7.9	0.95	1,069
Cotton seed cake (decorticated)	7.7	40.0	7.0	12.0	6.0	2.00	2,400
Groundnut cake	8.5	40.9	7.9	8.9	5.9	0.86	2,596
Doiled groundnut cake	6.7	48.6	2.2	11.2	10.8	2.24	2,328
Soybean meal	10.1	45.8	1.9	6.3	5.8	2.60	2,400
Mustard cake	8.7	35.1	14.1	8.2	9.2	1.20	2,373
Safflower cake (decorticated)	5.8	43.1	4.4	29.9	8.6	2.00	2,000
Sunflower cake	11.0	37.2	11.9	11.6	7.7	0.62	2,230
Til cake	9.3	39.1	9.3	4.7	12.6	1.50	2,200
Fish meal	7.4	43.1	4.3	3.6	37.5	20.80	1,834
Meat meal	6.8	55.0	12.0	2.5	18.0	4.20	2,400
Silk worm meal	8.0	67.0	2.2	3.9	12.0	5.40	2,800
Molasses	26.4	2.8	-	-	10.9	0.50	2,400

Tests for toxic substances : Test for the presence of toxic principles, would help for fixing safe level of inclusion of the ingredient in the diet. Test for few important principles for commonly used feed ingredients are given below. Routine test for the toxic principles will help in maintaining quality of the compounded feed ingredients for selecting feed formulation.

Ingredients	Test to be undertaken
Maize, jowar, wheat, rice, salseed meal, other cereal byproducts.	Moisture, tannin, aflatoxin, pesticides (Residual)
Groundnut extractions	Moisture, aflatoxin, adulterant tests for castor husk and mahua cake
Mustard oil cake/rapeseed meal extraction	Tannins, glucosides
Cotton seed meal	Gossypol
Soybean meal	Trypsin inhibitors, urease activities
Guar meal	Trypsin inhibitors, Guar gum (Residual)
Mineral supplements	Fluorine, vanadium and other toxic minerals

QUALITY CONTROL OF COMPOUNDED FEED

Quality control at the manufacturing unit should monitor the consistency of nutrient content in the finished product specified for the particular category of the birds (if the ration contains 22% protein, it should contain 22% only. It should not be 17% or 30% on subsequent batches). For the poultry producer, quality of a compounded feed means its efficiency of utilisation and sustaining high production (both egg and meat). Therefore, at the time of feed manufacturing, raw-materials are to be analysed, to be used in correct proportions (as per the calculations and suggestion of nutritionist) proper grinding and complete mixing are to be ensured. Variations in nutrient content in mixed feed may occur due to (a) ingredients variation for batch to batch (b) poor and improper mixing of ingredients resulting segregation of the nutrients (c) improper/wrong weighing of ingredients. For sustaining high production it is essential to monitor the consistency of the nutrient content in the compounded feed through regular analysis before and after manufacturing the feed. Presence of any toxic principles need to be identified and estimated for ensuing the safe level of the principles. Ingredients and finished products should be stored in dry and cool place. Measures must be taken to minimise the infestations by insect or rodent pests. Further, a separate area is also required for processing of feed, storage of ingredients and for finished products. Such an arrangement would help in proper cleaning and disinfestation of materials, stored in godowns. Feed should be stored for a short period only.

Above all proper effective quality control strategies and policies and personnel with authority in the feed manufacturing unit to ensure regular inspection of incoming materials, processing unit and outgoing finished products will only ensure effective quality control of feed from the manufacturing unit.

Analysis and quality control laboratory : It is not very difficult to establish a small analytical laboratory in every feed manufacturing unit. Such an arrangement would help the feed manufacturer small and medium or large units for determine proximate principles of incoming raw materials (moisture, protein, crude fibre, oil and total ash) without loosing much time. Large manufacturers can afford to establish a good laboratory with sophisticated analytical instruments for estimation of amino acids, fatty acids, trace minerals and all plant toxins in incoming feed ingredients and end products. Small and medium feed manufacturers can avail the facilities available with large feed manufacturers. Such type of arrangement would definitely help the feed manufacturers in screening the feed ingredients for their suitability and for preparing quality balanced feed. In places where number of feed units are located a central analytical laboratory may be established to serve the feed manufacturers on payment basis. This can be achieved either by research organisations or the feed manufacturers associations. Quality control laboratories are to be supervised by the qualified and experienced analytical chemist.

CONCLUSIONS

In view of the inclusion of large number of conventional/unconventional feed ingredients one must check and recheck all the nutritional aspect of the feed and more particularly for the presence of non-nutritional/toxic principles in the compounded feed. Therefore, strict implementation of quality control programmes with authority, at the manufacturing unit would go a long way in achieving and sustaining profitable poultry production.

"No Compromise on feed Quality"
"Quality increases the productivity and profitablity"

NUTRITION OF QUAILS AND DUCKS FOR MEAT AND EGG PRODUCTION

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Of the domesticated poultry, the chickens for egg and meat production have enjoyed a great deal of acceptability as sources of supplementary protein in human diet. Consequently, the annual output of eggs during the past 30 years increased well over 80 times to 30,000 million, and that of broiler chickens from a negligible of 4 million in 1971 was forcasted to have touched 400 million in 1996 (Anon, 1994). Besides, the production of ducks and quails both for eggs and meat production has also been gaining in momentum. The ducks although formed part of the village poultry ever since, the quails and partridges continued to enjoy the free jungle life as gamebirds except for a very small number reared in captivity for fancy. It is only during the seventies when hatching eggs procurred from the USA at the then Poultry Research Division of IVRI, Izatnagar for experimental purpose that the Japanese quail production for table delicacy came to be known in the Indian Poultry circles. After establishment of a good quail flock size, nutritional experiments with this avian species also started at CARI, Izatnagar (Kumar *et al.*, 1978; Reddy *et al.*, 1980; Verma, 1982).

Despite the impressive achievements in the Poultry sector, a big gap existed between the current eggs and poultry meat availability in relation to the minimum requirements of the Indian population. As per the recommended 180 eggs and 9.0 kg of poultry meat per capita per annum, the current eggs and meat availability has been estimated only at about 30 and 500 g, respectively. However, the Indian population largely being vegetarian, the per capita annual consumption of eggs varied from as low as 10 in the rural areas to as high as 170 in the metropolitans. Besides, the per capita daily availability of pulses and other vegetable protein sources has also been decreasing from 69 g in 1961 to 37 g in 1995 (Anon, 1995-96). In order to mitigate the problem of human malnutrition, eggs and poultry meat has been identified as an appropriate alternate source of high-quality protein, the production of which, however, calls for a befitting scientific approach to the nutrition and feeding of ducks and quails as well. This paper addresses itself to these aspects such that an efficiency in duck production with a larger rural base and that of quails in an organised intensive farming system could further be improved to take care of the interests of both the producers as also the consumers.

NUTRITION OF QUAILS

Nutrient allowances recommended for quails reared in the tropical climate for meat and egg production have been set out in Table 1.

Table 1. Suggested practical level of nutrients in feeds for Japanese quails (units/kg diet)

Nutrient	Unit	Quail broiler mash		Quail layer mash		
		0-2 wk	3-5 wk	0-2 wk	3-5 wk	6 wk
ME	MJ	11.71	11.71	11.50	11.50	11.50
	Kcal	2800	2800	2750	2750	2700
Protein	g	270	240	240	200	190
Minerals						
Calcium	g	8	6	8	6	3
Phosphorus	g	3	3	3	3	4.5
Sodium	g	2	2	2	2	2
Copper	mg	8	8	8	8	8
Manganese	mg	80	80	80	80	80
Iron	mg	100	100	100	100	100
Zinc	mg	80	80	80	80	80
Vitamins						
Vitamin A	IU	8000	8000	8000	8000	10000
Vitamin D_3	ICU	1200	1200	1200	1200	1200
Vitamin E	IU	50	50	50	50	50
Vitamin K	mg	3	3	3	3	3
Vitamin B_{12}	mg	5	5	5	5	5
Thiamine	mg	4	4	4	4	4
Riboflavin	mg	6	6	6	6	6
Niacin	mg	60	60	60	60	60
Pantothenate	g	50	50	50	50	50
Pyridoxine	mg	6	6	6	6	6
Biotin	mg	0.2	0.2	0.2	0.2	0.2
Folic acid	mg	1	1	1	1	1
Choline	g	3	3	3	3	3
Amino acid						
Lysine	g	13	12	12	11	8
Methionine	g	4.8	4.5	4.5	4.0	3.3
Meth.+Cystine	g	7.5	7.0	7.0	6.5	6.0
Arginine	g	15.7	14.0	14.0	12.0	10.0
Glycine	g	14.4	12.8	12.8	10.6	10.0
Histidine	g	5.4	4.8	4.8	4.5	3.7
Isoleucine	g	10.8	9.6	8.5	8.0	8.0
Leucine	g	18.9	16.8	16.8	14.5	14.3
Phenylala+Tyro.	g	18.1	16.1	16.1	14.0	11.7
Threonine	g	10.0	8.9	8.9	7.5	6.4
Tryptophan	g	2.7	2.4	2.4	2.1	1.8
Valine	g	11.9	10.6	10.6	10.0	8.8

Source : Data adapted from Shrivastav (1996)

Energy, protein and amino acids : Published reports based on studies made in the temperate regions indicate that the starting and growing quails performed optimally on rations with wide energy range from 2600 to 3000 Kcal ME/kg. Whereas on the basis of the work done in India on the nutrition of quails in the tropics, Shrivastav 1996 has recommended 2800 and 2750 Kcal ME/kg diet for the meat and egg production purposes, respectively. Raising of the dietary energy level from 2600 to 2800 Kcal/kg diet although did not influence weight gain but affected significantly the efficiency of feed utilisation for the birds tended to consume less on high energy diets to satisfy their energy needs.

As for dietary protein, the work done in temperate climate indicated quails to perform well on 24% crude protein diet to start with and which may be lowered to 20% during the 3 to 6 wk of age growing period (Shim and Vohra, 1984; NRC, 1994). The work done in India indicated a higher requirement of 27% of crude protein in diet to start with which subsequently is reduced to 24% in diet after 3 wk of age (Shrivastav *et al.*, 1980a). A poor biological value owing to amino acid imbalances associated with the antinutritional components inherently present in most vegetable-protein is probably one on the commonest factors responsible for an increased protein requirement (Verma and McNab, 1984; Verma and Shyam Sunder, 1985; Gowda *et al.*, 1996).

The possibility of lowering the dietary protein level through incorporating in diet of quails the good quality protein feedstuffs has also been explored. Shrivastav and Panda (1988) reported that inclusion of casein in diet of growing quails helped lower protein requirement to 24% for the white shell egg line whereas the liveweight of meat line Shrivastava and Panda (1987) suggested a dietary level of 0.48% methionine and 0.27% cystine at 27% protein and 2800 Kcal ME/kg were adequate for optimum growth. For optimum laying performance of quails the lysine and total sulphur amino acid requirements were estimated at 0.8% and 0.6%, respectively and which were not directly related to the dietary protein level of 16 to 22%.

Minerals : For satisfactory growth and skeletal development of growing quails in temperate zone the dietary levels for Ca and available P of 0.5 to 0.8 and 0.2-0.3%, respectively have been found adequate (Shim and Vohra, 1984). Whereas in the tropics Bisoi *et al.*, (1980) reported that 0.7% Ca and 0.2 to 0.3% av. P was needed for maximum weight gain and bone ash although 0.5% Ca and 0.2% av. P in diet were found to have been adequate (Reddy *et al.*, 1980). For egg production and sound eggshell quality 3.0% Ca in diet adequate (Shrivastava and Panda, 1986). The limestone, oyster shell or the egg shell meal were found to be equally satisfactory as sources of dietary Ca. The breeder males reared seperately can well be fed layer diet with 1.0% Ca (Shrivastava and Panda, 1983).

Information on the trace element requirement by quails is, however, scantly. For optimum growth, feed conversion and skeletal development, 0.8% Ca with 60 mg of manganese per kg diet was found adequate (Lalmingthanga, 1987). However, an inverse relationship in the dietary Ca and Mn levels has been observed. In laying quails, Shukla *et al.*, (1993a; 1993b) reported 80 mg Mn and 75 mg Zn per kg diet to be adequate for optimum production, egg quality and skeletal growth.

Vitamins : In a solitary study, Sachdeva (1987) observed that for satisfactory growth, feed conversion and reproductive performance of quails supplemental vitamin A of 6000 and 4000 IU/kg diet of the egg and meat lines was adequate.

NUTRITION OF DUCKS

In India, the duck production has largely been as the back water activity with not much attention paid to their nutrition and feeding. These are reared in small flocks in small ponds or some times go out into the rice fields, water streams, canals quails still improved even at 27% protein level thereby pointing to the importance of high quality protein sources in feed formulations.

Dietary protein plays an important role in body composition and carcass traits are, therefore, an important consideration in both evaluating the quality of protein feedstuffs as also for defining the protein requirement of birds. Shrivastava and Panda (1991a) examined body growth, meat quality and market possibilities of quail broilers that are influenced or associated with dietary protein level of 24, 27 or 30% upto the age of 3, 5, 7, 9 or 11 weeks. A decline in growth rate after 5th week of age irrespective of the dietary protein level had been observed. The carcass component weight, meat yield and profit over feed cost were maximum at 5th week of age and that the feed conversion efficiency was better at 27% protein level. A caloric:protein ratio of 96 at an energy level of 2800 Kcal ME/kg was optimum (Shrivastava and Panda, 1990) although quail broilers can be fed diets with C:P ratio of 107 at 2800 Kcal ME level during the 2 to 5-wk finishing period and marketed at 5-wk of age for better meat quality and profitability (Shrivastava and Panda, 1991b).

For realising optimum performance from layer quails reared in temperate zone, Shim and Vohra (1984) suggested 20% crude protein with 2800 Kcal ME/kg diet and observed that the dietary protein level higher to 23% was not beneficial. In the tropics, Kumar *et al.*, (1978) realised optimum production from layer quails fed 23% crude protein and 2900 Kcal ME/kg in diet, although these could still perform well on rations with lower energy level of 2500 Kcal/kg. The high protein requirement of 23% in the tropical climate also reflects on the poor quality of the dietary protein and/or an amino acid imbalance. In subsequent studies (Shrivastava *et al.*, 1993; 1994) involving different protein and energy levels at a constant limiting amino acid to energy ratio on the productive and reproductive performance indicated 19% crude protein at 2750 Kcal ME/kg to be adequate for quail layers and breeders.

Lysine and methionine are the two amino acids often limiting in most poultry rations, hence their requirement by quails for growth and production purposes was considered. Shrivastava *et al.*, (1984) reported that 1.3% dietary lysine was adequate for maximum growth and feed conversion efficiency. As for the total sulphur amino acids. the birds pick up green leaves, earthworms, snails, small fishs, insects and weeds. The overhead expenses on duck rearing are therefore negligible but their production is also low. Information on the scientific feeding of ducks in India is scanty, therefore, reports based on work done elsewhere have been considered. Information on the nutritional needs of the meat and egg laying ducks has been summarized in Table 2.

Table 2 Suggested nutrient levels in practical diets for ducks (Amount/kg feed)

Nutrient	Units	Phase		
		Starting (0-2 wk)	Growing/Finishing (2-6 wk)	Breeding/Laying
ME	MJ	12.97	12.97	11.72
	Kcal	3100	3100	2800
Protein	g	220	160	160
Amino acids				
Methionine	g	4.7	3.5	3.5
Meth+Cystine	g	1.8	6.0	6.0
Lysine	g	12.0	8.0	7.0
Arginine	g	12.0	10.0	8.0
Tryptophan	g	2.3	2.0	1.6
Minerals				
Calcium	g	6.5	6.0	27.5
Phosphorus (av.)	g	4.0	3.5	3.0
Sodium	g	1.5	1.4	1.4
Chlorine	g	1.3	1.2	1.2
Magnesium	mg	600	500	500
Manganese	mg	40	35	35
Zinc	mg	70	60	60
Selenium	mg	0.15	0.15	0.15
Iodine	mg	0.15	0.15	0.30
Vitamins				
Vitamin A	IU	4000	3000	4000
Vitamin D	ICU	500	400	500
Vitamin E	IU	20	5	20
Vitamin K	mg	2	1	2
Riboflavin	mg	4	3	4
Pantothenic acid	mg	12	10	12
Niacin	mg	50	50	50
Vitamin B_{12}	mg	10	5	5
Choline	g	2	1	1
Py oidoxine	mg	3	3	3

Source : Data adapted from Dean (1985)

NUTRITIONAL NEEDS OF GROWING DUCKS

Energy and protein: Like other avian species, the ducklings from 0.3 week of age also grow fast, and therefore it is necessary to supply a good quality protein and energetic diets during the period. Although the bioavailability of energy in most feedstuffs appears to be similar for ducks and chickens but the former appears to derive slightly more ME from the diet than chickens (Mohamad *et al.*, 1984) and convert more of it into body fat. Dean (1978) reported optimum performance of ducklings fed diets varying from 9.20 to 11.97 MJ ME/kg.

As for protein, Oluhemi and Fetuga (1978) reported 24% dietary crude protein for ducks raised for meat from 0-8 wk of age in the tropical climate. When expressed per unit of dietary energy, the protein requirement for starter Pekin ducklings fall with in the range of 17.5 to 17.7 g protein/MJ ME. Other workers also reported almost similar requirements for different breeds of ducks during the starting phase and which decreased considerably to 9.6 to 10.3 g protein/MJ ME during the late finishing phase (Leclercq and de Carville, 1975). In a study on the protein requirement of muscovy ducklings, Ali and Ahmad (1990) observed 21, 18 and 15% dietary crude protein level as optimum for starters (1-28 d), growers and finishers (25-70 d) and at market age (84 d), respectively. Roy and Choudhury (1994) stated that the protein requirements of Pekin ducklings during the 1-3 wk and 4-12 wk periods depends on age at marketing. When marketed at 6, 9 or 12 wk of age, a dietary protein level of 22-18%, 20-16% and 18-14% will suffice.

Amino acids : The methionine requirements of ducklings for optimal early growth were estimated at 0.47% or 0.38 g/MJ (Dean 1977; Dean and Shen, 1981; Elkin *et al.*, 1985). The requirements for leucine, isoleucine and valine for male ducklings (8-20 day of age) were estimated at 1.26, 0.63 and 0.78%, respectively in diet containing 18% crude protein and 11.0 MJ ME/kg (Yu and Shen, 1984). Dean and Shen (1981) projected 1.22% dietary lysine during the early growing period and which was reported to be low (1.06%) for male ducklings (Chen and Shen, 1979), and much lower (0.65 and 0.59%) for the muscovy ducklings during the growing periods of 3-6 and 6-10 week, respectively (Leclercq and de Carville, 1978). The requirement for arginine (Chen and Shen, 1979) and tryptophan (Wu *et al.*, 1984) were estimated at 1.08% and 0.23%, respectively.

Minerals: Growing Pekin ducklings grew well on a diets containing 0.56% Ca (Dean *et al.*, 1967) and 0.60% total P and that all ducklings diet if the diet was free of sodium (Dean, 1972). Dietary addition of about 0.2-0.3% NaCl was therefore necessary although higher level between 0.4 to 0.8% have been advocated (El-Deek and Shebl, 1988). The requirements for Mn and Zn (Wu and Shen, 1978), and selenium (Jing *et al.*, 1987) have been suggested at 35, 68 and 0.03 ppm, respectively for realising optimum growth of ducklings.

Vitamins : Although the vitamin A requirement of ducklings was estimated at 2200 IU/kg diet but a generous supply has always been advocated for safety purpose in the practical duckling rations. Similarly, addition of 300 ICU of Vit. D, 27 IU Vit. E (Jager *et al.*, 1969), 580 to 1020 mg of choline (Dean 1972) and 25 mg of niacin (Wu *et al.*, 1974) per kg diet has been recommended. The birds being usually on forage are expected to pick up enough Vit. K to meet their needs.

NUTRITION OF DUCKS FOR EGG PRODUCTION

Protein and energy: For satisfactory egg production and egg size, dietary crude protein level of 19% and ME concentration of 11.8 MJ/kg was found optimum (Pan *et al.*, 1981), although the best feed conversion was reported at 11.92 MJ ME/

kg. In India, Prasad *et al.*, (1988) reported the optimum protein and energy levels in diet of Khaki Compbell females from 1-6 wk of age at 16.0% and 10.9 MJ/kg, respectively. The lower protein and energy levels are probably in accordance with the low production level of stock as also the opportunity to foraging.

Amino acids : The supplemental DL-methionine to provide 0.3% level in diet of laying ducks gave the best feed efficiency and egg production. Similarly, an optimum lysine level for egg production and feed conversion efficiency was found to be between 0.85 and 1.0% (Chan *et al.*, 1981). Employing Tsaiya ducks, (Chan *et al.*, 1984) observed that diet containing 18% crude protein, 3.0% Ca, 0.46% av. P, 0.85% leucine, 0.85% isoleucine, 0.86% valine with 11.5 MJ ME/kg though gave a satisfactory performance but it could be further augmented through supplemental lysine and leucine.

Minerals : Ducks are prolific layers and therefore the demand for calcium and also for phosphorus are high, Wu (1978) recommended an optimum Ca level of 2.5 to 3.1% and that of total P 0.5 to 0.6% in diet of the brown domestic birds. Whereas Pan *et al.*, (1977) recommended a total dietary P level of 0.7% and the av. P of 0.47%. The sodium requirement for breeding ducks has been estimated at 0.14% (Dean, 1978; NRC, 1984) although for optimum egg production, egg weight and feed efficiency 0.19 to 0.28% dietary sodium is recommended (Chen, 1984). For breeding ducks the NRC (1984) recommended 25 ppm of Mn in diet. However, Pan *et al.*, (1984) at the Duck Research Centre, Taiwan, observed that addition of 40-60 ppm Mn to a corn-soya based diets with initial Mn content of 23 ppm was beneficial in improving fertility and hatchability. An optimum Mn level in laying duck diet should be around 80 ppm (Pan *et al.*, 1985). In a solitory report, Lee *et al.*, (1984) observed that the addition of 30 ppm Zn to a corn-soybean meal diet was adequate.

Vitamins : For optimum production, egg weight, fertility and hatchability, the brown domestic ducks needed added vitamin A upto 10,000 IU/kg diet. For better laying performance from ducks 20-30 mg DL-alphatocopherol acetate per kg diet was useful. Studies on the linoleic acid needs of ducks (Chen *et al.*, 1981) however remained unconclusive. Choline was also beneficial for ducks and a minimum level of 1200 mg/kg diet for Tsaiya ducks was recommended (Chen *et al.*, 1993).

Conclusions : Quails and ducks are important avian species and their meat and eggs find vide acceptability as sources of supplemental protein in diet of human beings. The nutritional needs and feeding systems for these birds under the practical Indian conditions have however not been spelt out and developed fully. In absence of such information, nutritional data as applicable to chickens has often been applied. More investigations are however needed to better understand their nutritional needs in order to realise optimum returns and at least cost through utilizing locally available feed resources and common housing and managemental practices.

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PROSPECTS AND CONSTRAINTS FOR MEAT PRODUCTION : PERSPECTIVE 2020

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Livestock sector is an important component of India's economy in terms of income, employment, equity and foreign exchange earnings. The value of output from livestock sector was 17,690 crores in 1990-91 at the current prices. This was 7.42% of India's gross domestic product (GDP). The value of livestock products has registered an average simple growth of 6.69% per annum over the period of 1980-81 to 1990-91, its share however, in GDP has almost remained the same. The total contribution from livestock in 1994 was 44, 474 crores, milk being the single largest contributor (Rs. 29, 217 crores). Besides milk, livestock sector provides meat (392 crores), leather (3,758 crores), draught, fibre and manure.

Livestock sector has considerable impact on rural employment. About 73% of rural households own livestock. National Commission on Agriculture (1976) projected 42.5 million man-years as employment potential by the turn of the century. NCEAR estimates showed that 83% of adult male, 97% of adult female and 77% of child labour time is used in livestock rearing. Even landless labour and other poor population of society participate in livestock production.

India has the largest livestock population, comprising of 192 million cattle, 78 million buffaloes, 45 million sheep, 117 million goats, 10.5 million pigs and 435 million poultry (FAO, 1990). India produces 62 million tonnes of milk (second largest), and 3.8 million tonnes of meat.

Table 1. Value of meat and meat products from livestock sector (1991-92)

Products	Value (Rs. Crores)
Beef	802
Mutton	2490
Pork	530
Poultry meat	3029
Meat products	248
Hides	340
Skin	343
Other byproducts	117
TOTAL	7899

MEAT INDUSTRY

Inspite of big potential because of large livestock population and a competitive edge in the international market, due to cheap labour, the meat industry in India is under developed. It is still very much unorganised and has grown very slowly, although lately it is growing very fast (annual growth 27%). There are many reasons for the slow growth like negative attitude of public towards the meat, higher cost of modern abattoirs, fequent objections by the public about the location, socio-political pressures, etc.

During 1991-92, India produced 3.866 million tonnes of meat valued at 790 crores (Table 1 and 2). The plus points about Indian meat is that it is of lean type and is preferred in world markets. A large number of meat importing countries are in the proximity to India. The continuing demand for sheep and goat meat in the domestic market limits then availability for export. The export of beef is banned. Buffalo therefore, is the most prospective economical species in the market for milk as well as meat leading to a large surplus available for export. India has a comparative advantage and is in a competitive edge to produce meat animals and export buffalo meat and meat products.

Export of Indian leather goods is fast increasing. It is estimated that Indian leather goods export would be about 18,000 crores by 2001 A.D. This will lead to increased demand for raw hides and skins at relatively higher prices.

Table 2. Export of meat and meat products

Quantity : 000 tonnes
Value : Rs. in million

	1992-93		1993-94		1994-95	
Items	Qty.	Value	Qty.	Value	Qty.	Value
Buffalo meat	82.5	2144	102.1	2815	116.1	3244
Sheep/goat meat	7.4	402	12.6	619	10.8	660
Processed meat	0.2	9	0.2	17	0.2	13
Processed Chicken	-	1	-	3	-	1
TOTAL	90.1	2556	115.1	3454	127.1	3918

At present the export of poultry meat is insignificant but there is a tremendous potential for export of poultry and poultry products specially to middle east and south east Asian countries. The cost of production, processing, packaging from Indian broilers is about US $ 1200 per tonne. With the operationalisation of WTO, the subsidy on livestock and poultry is being removed in the developed countries. Consequently, India has now emerged as a competitive supplier. Already the prices of poultry meat in the international market have increased and are in the range of US $ 1300/tonne. These will further increase after July. '97 with the full implementation of the GATT agreement. The devaluation of rupee vis-a-vis dollar will encourage the export of poultry meat.

EXTRACTION RATES OF ANIMAL FOR MEAT PRODUCTION

It is estimated that about 60 million sheep and goats, 20.3 million bovines (cattle and buffaloes) and 10.40 million pigs are slaughtered every year leading to the extraction rates of about 30% for small ruminants, 10% for bovines and 99% for the pigs (Table 3). These extraction rates are quite small as compared to the other Asian countries looking at the availability of large number of animals in the country and deficiency of feeds and forages. The natural grazing areas are reducing and increasing extraction rates will permit better nutrition to high milk producing animals. The draught animal power will not decrease.

Although the number of animals available for slaughter is comparatively high in the country, meat yields per animal rank amongst the poorest when compared to world's average. Carcass weight of buffalo, sheep, goat and pigs in India is estimated to be 100, 9,9 and 30 kg, respectively, which is very low. It is mainly because most of the animals slaughtered are not exclusively reared for meat purposes. Meat industry is rather a by-product and a sub-system to an animal system which is mainly geared for production of draught, milk, fibre and manure. Production systems under contractual farming with the small hold farmers need to be developed around the mechanised abattoirs to supply the raw material of good quality so as to fetch better prices of meat in the international markets.

Table 3. Livestock population, slaughter rate and meat production in India (FAO 1993)

Species	Population (000)	Slaughtered (000)	Slaughter rate (%)	Meat Production (000 MT)
Cattle	192700	12388	6.43	1276
Buffaloes	78555	8565	10.90	1182
Sheep	44608	14100	31.61	169
Goat	117547	46600	39.64	466
Pigs	10547	10493	99.49	367
Chicken	435000	-	-	406
Meat Total	-	-	-	3866

PRESENT EXPORT OF MEAT AND MEAT PRODUCTS AND FUTURE TRENDS

Production potential and domestic consumption of meat is presented in table 4. The major export of meat and meat products is from buffalo, sheep and goats.

Table 4. Meat production potential, domestic consumption and export surplus by 2000 A.D. (estimates as per Ideal production system)

	Production Potential (000 MT)	Domestic consumption (000 MT)	Export Surplus (000 MT)	Export Value (Rs. M)
Buffalo meat (Boneless)	1880	365	1515	45450
Mutton	248	170	78	4680
Goat meat	801	550	251	15060

Export value of buffalo meat assumed at 1000 US dollors/M.T.
Export value of mutton and goat meat is assumed at US dollors 200 per M.T.

Buffalo meat : India has more than half the world's population of buffaloes (53%). The world production of beef and veal meat is estimated at about 52.9 million tonnes. India's share is around 4.6% (Table 5). In 1994 India exported 150,000 MT of buffalo meat (meat and veal) valued at US $ 130 million. The amount is very less as compared to the potential. As per census of 1987, the buffalo population upto the age of 3 years is as follows :

	Males (Million)	Females (Million)	Difference (Million)	Remarks
Under 1 year	5.21	10.7	5.5	killed by farmers
1-3 years	3.7	10.2	6.3	slaughtered

Every year about 5.5 million calves are removed from the system, thus incurring a loss of about 60 crores. These calves could be salvaged for meat production leading to improvement in the economic condition of the farmers. The annual growth in buffalo population is about 2%, the present availability for disposal of male calve is 14 million and adult buffalo is 10 million but only 8 million of total are slaughtered. It could be increased to three fold without affecting milk or draught production. According to an estimate from APEDA in a year about 20 million buffaloes will be available producing about 2.5 MMT of boneless meat valued at 10,000 crores.

Sheep and goat meat : About 62 million sheep and goats are slaughtered annually in India. The world trade in sheep and goat meat in 1992 was estimated at 10.38 MMT of which India's share was 0.9 million MT (FAO 1992). India's export of goat and sheep meat during 1992-93 was about 14000 tonnes valued at Rs. 780 million.

The sheep population is growing at the rate of 1.14% and goats at 0.9%. Since mutton is a preferred meat in India and there is a high domestic demand, the exportable surplus is only about 14,000 MT. There is however very little possibility of increase in the export by 2001 A.D. since the domestic demand will also increase.

Poultry meat : The world's trade in poultry meat is estimated at about 2,500 MMT valued at US $ 4, 500 million. Export of poultry meat from India has started recently. The export during 1991-92 was about 250 MT valued at Rs. 11.5 million.

Pig meat : The present pig production system in India is unable to capture any international market although it has a big potential provided we change the production system.

Animal casings : India's export during 1991 was about 178 MT valued at Rs. 510 million. This was about 7% of the world's trade in natural casings in terms of value. The export has increased to Rs. 90 million in 1992-93. The export potential is estimated at 1,535 MT valued at Rs. 520 million in 2001 A.D.

Processed meat : Small quantities of processed meat i.e. 0.5% of total livestock produce is exported mainly to middle east and Malaysia in the form of meat preparation, meat extracts and meat juices. The annual growth is approximately 40%.

Bone, bone products, horn and hoof meal : Considerable quantities of these products are exported. In 1992-93 export earnings from these products amounted to Rs. 834.1 million, the main products being ossein, bone grist, crushed bones and gelatin.

Leather : The value of leather and leather goods was Rs.5957 crores in 1991 with an export of Rs. 3219 crore which is likely to increase to Rs. 30220 crores in 2001 with an export of Rs. 18,000 crores.

Table 5. World production of meat and meat products and share of India in 1993 (000 Tonnes)

	Meat Total	Beef & Buffalo meat	Sheep & Goat	Poultry Meat	Pig Meat	Offals Edible
World	185917	52969	9808	46072	73452	13374
India	3992	2458	629	406	337	485
Percent	2.1	4.6	6.4	0.9	0.45	3.6

Source : FAO Production Year Book 1992.

IDENTIFICATION OF MEAT AND MEAT PRODUCTS WITH COMPETITIVE EDGE

With the signing of GATT agreement establishment of the World Trade Organisation, the subsidies given by the developed countries on livestock production will be drastically curtailed and consequently meat products from these countries will further become costlier and would not be able to compete with Indian meat. The Indian meat is cheaper as government does not give any subsidy for livestock rearing.

The boneless buffalo meat is being exported at US $ 800 to 1200/ tonne depending on the quality of meat. The Australian beef is traded on US $ 2500 to 3500/ tonne. Some of Australian cuts are even traded at around US $ 8000/tonne.

The male buffalo calves could be reared with advanced feeding management practics and can fetch a better price in the international market.

Sheep and goat meat is another product which is of a better quality. The Indian mutton/chevon is traded at about US $ 3, 400 as compared to Australian mutton which is traded at US $ 2, 800 because of a peculiar flavour in Australian lamb which is not liked by the Arabs.

Poultry meat, being traded at US $ 1300 per tonne in the international market, will now motivate Indian producers to export the poultry meat since the present cost of production, processing and packaging is around US $ 1, 200. The price of poultry meat in the international market will further increase from the July, 1997 with the operationalisation of the WTO.

MAJOR CONSTRAINTS TO MEAT EXPORT

Some of the factors which hampers our exports are given below. If these bottlenecks are removed the meat industry will progress at enhanced rates.

Lack of modern integrated slaughter houses : There are about 3643 recognised slaughter houses with the municipal authorities which lack adequate facilities and basic amenities required for hygienic production of meat. The capacity of these units varies from 100-500 for large animals and 25-800 for small ruminants per day. These abattoirs fall short of the standards and norms required by overseas customers. Lack of strict vigilance and inspection, poor quality control, absence of centralised certification system, etc. have further made the situation difficult.

The need of the hour is to establish modern integrated mechanised slaughter houses cater the increasing domestic requirement and for export to the existing and new markets. There are about 5 modern slaughter houses with Hind Industries Limited, Allana, Al-Kabeer, Punjab Meats and Deonar (Public Sector). Besides these, there are about 30 modern meat processing plants which however, receive the dressed carcasses from the municipal slaughter houses. Many countries like Malaysia, Jordan etc. have stopped purchasing meat from the exporters who do not have their own modern abattoirs. The new markets in Iran, Philippines, Indonesia and others are insisting for the production of meat in the modern slaughter houses. There is a potential requirement to establish atleast 50 more mechanised abattoirs to utilize about 25.0 million surplus buffaloes annually. Each abattoir should have a facilities of slaughtering 0.5 million animals annually.

Lack of disease free zones : The economic feasibility in terms of cost benefit ratio of the proposed establishment of disease free zones is highly positive. The only

Indian company which has started the concept of disease free zone in the command area is the Hind Agro Industries Limited which has started backward integration with their modern abattoir. This has been taken up in two phases. In Phase I district Aligarh has been taken. In Phase II adjoining districts will be taken. There is no rinderpest disease in U.P. The present vaccination for FMD, HS, BQ. has been started where in about 80% of the animals are vaccinated besides deworming of male calves for veal production of the farmers.

Large human population/high demand : Another factor which hampers our export performance is our huge human population. Precise calculation of local meat demand is difficult and prone to variation. However, for purpose of calculation the minimum requirement of meat, it is assumed that 1/3rd of animal protein requirement (15g) should be provided by meat sources. This accounts for 30g carcass meat or 5g of meat protein. Assuming 70% of 90 crore human population being non-vegetarian, the demand for meat is placed at 6.8 million tonnes. The present meat production (3.0 million tonnes) should be increased by 60%. This is possible even at current population by either increasing the productivity of meat animals or through higher slaughter rate through effective culling of unproductive and excess buffaloes. The buffalo meat is consumed by 10-15% of the non-vegetarian population, which leads to a large surplus available for export than for the mutton-which is consumed by almost all the 70% of non-vegetarian population.

Lack of vertical integration between production and processing : In private sector, modern state of art mechanised abattoris are coming up primarily to cater the export markets. These abattoirs have higher intake of animals (500-2000/day in three shifts), eco-friendly and fully integrated which utilise all the slaughter house byproducts like blood, offals, bones, hides etc. However, these abattoirs are not promoting the backward integration with the livestock production systems, which is really very much needed at present because of large intake of raw material.

The Hind Agro Industries Limited has started the raising of buffaloes, sheep and goats and plan to achieve production of all the raw material under contractual farming with in a period of 3 years.

Insufficient cold chain : There are insufficient facilities for refrigerated transport from abattoirs to the air and sea ports. Similarly, the storage facilities are also not adequate. APEDA has suggested 200 transport units with chilling facilities.

Lack of quality control : At present no quality standards are followed by exporters and often complaints are received from the importing countries. Strict standards need to be adhered.

POLICY ISSUE AND REGULATORY MEASURES NEEDED TO IMPROVE EXPORT OF MEAT

There is a total ban on export of beef and beef products based on socio-religious sentiments rather than the economic consideration. Large number of cattle are being smuggled into Pakistan and Bangladesh for meat purpose illegally which deprive the livestock farmers and the government of sizeable economic returns. A more positive approach is to lift the ban on the export of beef and culled cattle. This will help in the efficient utilisation of available feed resources.

There is restriction in some states on the slaughter of buffaloes and bullocks. There is also restriction pertaining to age and reproductive status of the animal. Farmers should have the right for disposal of animals as they deem fit. These slaughter restrictions are hampering the production system to the disadvantage of the farmer. These restrictions were introduced to protect good productive buffaloes, cows and bullocks from slaughtering several decades ago.

As per the present slaughter policy, only unproductive and useless buffaloes should be slaughtered. The meat from spent animals is not of a good quality. Therefore, it is necessary that young male calves should be reared specifically for meat production. The term "useless" should be removed from the guidelines and a comprehensive policy document should be prepared based on the present research findings.

The input services for livestock production like breeding and treatment need to be privatized. At present the total coverage for artificial insemination is only 12% which need to be privatized.

To produce hygienic meat from buffaloes, the government should encourage to develop and establish integrated eco-friendly meat plants and make use of all byproducts available at the plant. Thses plants should be located in animal production zones.

From the processing plants to the ports of export a refrigerated container service (rail or road) should be available on daily basis. Cold stores with storage capacity for 3 months should be established at both sea and air ports. Most developed countries provide transport subsidy from port of export to the port of disembarkation. The present GATT regulation provides for 10% subsidy by the govt. for competitive exports. The government should provide necessary incentives through economic carriers in this sector to increase competitiveness.

PROMOTION

Publicity and promotional efforts are necessary to highlight HALAL method of slaughter practised and positive aspects of Indian buffalo meat such as lean characteristics, free from hormones/additives, and nutritional value specially in Muslims countries. General publicity of Indian meat is also necessary in target markets such as Egypt, Saudi Arabia, Iran, Iraq, Turkey, Singapore, Hongkong and CIS Countries.

It is also necessary to educate the public through print and visual media that slaughtering is a must to maintain the balance in eco-system. Animal production must be based on the carrying capacity of the land and failure to observe that may result in degradation of grazing resources and eventually affect the eco system.

Unfortunately, of late, there have been few reports in the media against the slaughter and opening up of new modern mechanised abattoirs due to some religio -political pressure. The public needs to be properly educated on this account.

There is a need to establish National Meat Development Board on the lines of National Dairy Development Board to further boost the production of meat and poultry in the country.

MARKET INTELLIGENCE

Market intelligence and export services are totally absent. APEDA collects and disseminates information on general international exports. It is expected to work for the promotion of agro-exports. It is suggested that APEDA should have market intelligence bureau which may be charged with the responsibility of gathering market intelligence and develop strategy for promotion of Indian meat in the potential export markets. New markets need to be developed for which quality meat is required. This is only possible if more modern abattoirs are established.

Human resource development in processing and packaging is required. It should be made as an integral part of modern meat industry.

FEEDING STRATEGIES FOR BUFFALO MEAT PRODUCTION IN INDIA

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Indian farmer looks after female buffalo calves with greater care and neglects the male calves. Male calves usually subsist on left overs of other animals and finally die at an early age. With better care and management of such calves, the potential of meat production can be achieved which will be a considerable income generating source for the farmers. With the establishment of modern abattoirs at Chandigarh in Punjab and Aligarh in U.P; farmers in Northern India have started giving attention on economics of animal rearing and raising buffalo calves for meat production. Therefore, time has come to explore the meat production potential of these buffalo broilers by following economical and cheaper feeding strategies.

BUFFALO MEAT PRODUCTION POTENTIAL

As per a recent estimate[1], India possesses 79.0 million buffaloes which produced 1.2 mmt of meat and 0.9 mmt of hides during the year 1994. Roughly half the population is comprised of breedable buffaloes. The meat production could be improved substantially if the available male calves are reared scientifically for meat production. The demand for buffalo meat is generally increasing not only for local consumption but also for export. It is anticipated that the demand for buffalo meat by the turn of the century will be about 3.0 million tonnes.

FUTURE PROJECTIONS FOR BUFFALO MEAT PRODUCTION

India had buffalo meat production potential as high as 1.0 million tonnes in 1985. This included 0.025 million tonnes from calves, 0.318 from steers and 0.660 million tonnes from adult buffaloes (IDCS, CFTRI, 1987). The recent estimate is presented in Table1.

EXPORT POTENTIAL OF BUFFALO MEAT

The popularity of buffalo meat has increased in the recent years throughout the world due to its high content of lean meat. There is a good demand of buffalo meat in the Middle East Countries like Jordon, Kuwait, Behrin, Qatar, UAE etc as India is geographically closer to these countries and transportation cost of meat is lower, delivery is quicker and meat reaches the markets in a fresher condition as compared to other competing countries. Malaysia is the major country which is importing buffalo meat from India. The total export of meat in the recent past years is presented in Table 2. The abattoirs those are catering to the needs of export are situated in Rudraram (A.P), Aurangabad (Maharashtra), Derabassi (Punjab); Nanded and Goregaon (Maharashtra) and Usgaon (Goa). A few modern abattoirs are in offing, the prominent one is in Aligarh (U.P).

Table 1. Projected buffalo meat production

Year	Total No. of animal (Million)	Male Buffalo Calves			Adult Buffaloes			Total	
		Surplus for meat purpose (Million)	Meat prod. (000 MT)	cost (Rs.) (Million)	Surplus for meat Purpose	Meat Prod. (000 Mt) (Million)	Cost (Rs.) (Million)	Meat Prod. (000 MT)	(Rs.) (Million)
1987	76.8	11.0	660	19800	5.4	540	12960	1200	32760
1994	87.4	13.1	786	23580	8.4	840	20160	1626	43740
2001	96.8	14.1	870	26100	101	1010	24240	1886	50340
2015	125.8	18.0	1080	32400	13.1	1310	31440	2390	63840

* *Population growth 2% per year.*
* *6-7 year old male bull calves or lactating animals to be declared surplus for meat to the extent of 15%.*
* *Average weight of male bufalo calves 200 kg and bone free meat 60 kg calf.*

Table 2. Data on meat export from India

Items	1990-91		1991-92		1992-93		1993-94	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value
Mutton and Chevon	8682	31.2	9700	47.0	13700	78.0	12808	61.9
Buffalo Meat	62608	108.4	85300	183.0	82200	214.0	102077	281.6
Processed Meat	159	0.8	193	1.1	300	2.	-	0.70
Animal Casings	-	7.2	-	6.9	-	9.00	-	-

Qty=tons, Value=Rs. Crores (US$=Rs.34.00)

QUALITY ASPECT OF BUFFALO MEAT

Buffalo meat is either similar[2] with other meat or it is superior in some quality attributes. The chemical composition of buffalo meat shows higher protein content. The hydroxy proline content is comparatively less in buffalo meat than beef. It contains almost all the essential amino acids and some of the amino acids like lysine, methionine and leucine are at higher level as compared to beef. It is well established that meat from ruminant species is rich in saturated fatty acids and low in polyunsaturated fatty acids (PUFA). However, buffalo meat contains high proportions of PUFA.

GROWTH PRODUCTION OF BUFFALO CALVES THROUGH NATURAL SUCKLING/CALF STARTER

Natural suckling is a common practice with farmers in villages and small dairy units having 1-10 buffaloes. Upto 3 weeks, calves are allowed to suckle 2-4 liters of milk/day in two milking, however, from the 4th week onwards a drastic cut is made. The calf is just used to stimulate the let down of milk. Male buffalo calves particularly suffer more in this respect and show slow growth rate. However, when the buffalo calves are properly suckled, an average daily gain of 0.356 kg from birth to 30 days was observed[3]. The conversion rate was high, as 9 kg buffalo milk was required/kg carcass weight. Another worker[4] reported an average daily gain of 0.581 kg in the first week and 0.848 kg in the 12 th week in properly suckled Murrah calves.

On organised buffalo farms, buffalo calves are weaned immediately after parturition and reared in calf pens. For the first three days they are fed colostrum and then upto 14th day fixed quantity of whole milk. From the 15th day to the 60th day, whole milk is gradually replaced with calf starter. Number of experiments conducted at NDRI, Karnal revealed that the calves when fed milk alone @ 1/10th of their body weight show growth rate between 388-490g/d with average birth weight of 25.0 kg.

FEEDING STRATEGY FOR REARING BUFFALO CALVES ON ALL FORAGE DIET

Forages are cheaper source of nutrients than concentrate feeds. The feeding cost of animals is 60-70 percent of the total cost of animal production, of which concentrate alone constitute 60 percent of the total feeding cost. The supply of green fodder/silage/hay throughout the year can be maintained through conserving the surplus fodder as silage (from non-legume) and hay (from legumes). There are number of reports[5] where it has been shown that feeding buffalo calves on all forage diets can reduce the cost per kg gain to the extent of 30-40 percent.

The effect of replacing concentrate mixture with cowpea hay at 33% (T-I) and 66% (T-2) levels was studied [6] and a body weight gain of 480, 507 and 487 (g) in control, T-I and T-2 groups was obtained without affecting utilization of nutrients. The cost of feed per kg gain was reduced by Rs. 1.05 and Rs. 1.86 in the two treatment groups, respectively. In an another study[7] the effect of replacing concentrate mixture at 100% with cowpea hay (T-1) and berseem hay (T-2) was investigated. The average daily gain of buffalo calves were, 530, 502 and 499g in control, T-1 and T-2 groups, respectively. The replacement value of cowpea and berseem hays at 100% level were 1.35 and 1.25 kg for 1 kg concentrate mixture. The cost per kg gain in Control, T-1 and T-2 groups were Rs. 8.40, 4.80 and 4.90, respectively (Table 3).

Table 3. Effect of replacement of concentrate mixture with berseem hay (100%, T-1) and cowpea hay (100%, T-2) in the ration of growing buffalo calves (84 days)

Particulars	Control	T-1	T-2
DM intake kg/100 kg BW	2.70	2.80	2.70
Initial Body Weight (Kg)	115.7±8.6	115.1±9.10	118.6±6.5
Final Body Weight (Kg)	160.54.70	156.0±8.70	160.5±5.5
Body Weight gain (g/h/d)	536	563	537
DCP intake (g/d)	378	376	357
TDN intake (kg/d)	2.54	2.44	2.32
Cost/kg gain (Rs.)	8.40	4.80	4.90

Similarly, in another study[8] effect of replacement of concentrate mixture with dried ryegrass at 50 and 75% levels using bajra silage as basal roughage was studied. The daily average weight gain were, 524, 509 and 502 g in Control, T-1 and T-2 groups, respectively. The digestibilities of DM , OM,energy, CP and EE were similar in all the groups. The cost per kg gain in body weight was Rs. 8.05, 5.58 and 4.23 in Control, T-1 and T-2 groups, respectively. The replacement value of 1 kg concentrate mixture was 1.31 kg of dried ryegrass.

Table 4 Effect of replacement of concentrate with dried ryegrass + berseem (T1) hay and ryegrass + lucerne hay on nutrient utilization and growth production in buffalo bull calves

Particulars	Control Quantity Consumed (kg)	Cost (Rs)	Treatment -1 Quantity Consumed (kg)	Cost (Rs)	Treatment -2 Quantity consumed (kg)	Cost (Rs.)
Concentrate mixture	210	462	-	-	-	-
Berseem+RG Hay (50:50)	-	-	269	188.3	-	-
Lucerne+RG Hay (50:50)	-	-	-	-	269	188.3
Pearlmillet silage	100.8	151.2	840	126.0	840	126.0
Total Cost of Feeding/ Animal/84 days (Rs.)	-	613.2	-	314.3	-	314.3
Gain in Weight (g/h/d)	521	-	534	-	542	-
DM Consumed (kg/d)	6.51	-	6.58	-	7.26	-
Feed : Gain ratio	12.5:1		12.3:1		13.4:1	
Cost/kg gain (Rs.)	14.02		7.02		7.02	

Note : Cost of CM, bajra silage, B+RG Hay, L+RG Hay were taken as 220, 15, 70, 70 per quintal respectively.

Recently, the authors studied[9], the effect of replacement of conventional concentrate mixture with dried ryegrass grown in mixture with berseem/lucerne (50:50) in the ration of growing buffalo calves. The replacement value of ryegrass + berseem hay (T-1), and ryegrass + lucerne (T-2) for 1 kg concentrate mixture was 1.25 and 1.26 kg based on *in vitro* digestible organic matter. At similar live-weight gain, the cost per kg gain in Control, T-1 and T-2 groups was Rs 14.02, 7.02 and 7.02 respectively (Table 4).

From these studies it is very clear that buffalo calves can be reared most efficiently and economically on all forage diets. So the strategy for buffalo meat production may be adopted by feeding these calves a combination of legume and non-legume forage and before slaughter they can be fed a finishing ration containing high energy and low protein concentrates for 10-15 days.

FEEDING STRATEGY BASED ON AMMONIATED WHEAT STRAW AND GREEN FORAGE

If ammoniated wheat straw is fed alongwith green berseem and available cereal energy sources, buffalo calves can be reared most economically. In a recent study[10], comparative utilization of wheat straw + green berseem+ concentrate mixture (Control) ; ammoniated oat straw + green berseem + 1 kg wheat (grain) (T-1) , ammoniated oat straw + green berseem + 1 kg barley (grain) (T-2); ammoniated wheat straw + green berseem + 1 kg wheat grain (T-3); and ammoniated wheat straw + green berseem + 1 kg barley (grain) (T-4); was studied by feeding straw and green berseem *ad lib* to 1 year old growing buffalo calves. The average daily gain of heifers was 503, 665, 607, 578 and 572g in control, T-1, T-2, T-3 and T-4 groups, respectively during 120 days. The cost per kg gain (Rs) in the Control, T-1, T-2, T-3 and T-4 groups was Rs.13.47, 8.42, 9.01, 9.80 and 9.84 respectively. In another similar study[11] effect of feeding ammoniated wheat straw + green berseem *ad lib* + three available energy sources (cereals) on nutrient utilization and growth production was studied (Table 5).

Table 5 Growth production in buffalo calves fed ammoniated wheat straw+cereal energy sources

Particulars	Conc. Mix.	Ammoniated wheat straw +berseem+		
		1.5 kg maize grain	1.5 kg wheat grain	1.5 kg barley grain
DM intake kg/100 kg B.W.	2.74±0.02	2.86±0.12	2.98±0.09	2.87±0.77
Initial Body Weight(Kg)	97.0±3.20	89.60±2.70	85.40±3.90	2.60±2.9
Final Body Weight	158.40±9.70	154.80±6.70	154.0±4.30	152.0±4.40
Body weight gain(g/h/d)	512	585	572	578
Cost/kg gain (Rs)	12.80	7.40	7.43	7.14

RECENT WORK ON GROWTH PRODUCTION ON BUFFALO CALVES BASED ON HIGH/LOW CONCENTRATE DIETS

Growth production in buffalo calves has been reviewed by various workers[12-14]. Growth trial was conducted at IVRI, Izatnagar (India) on buffalo calves kept on different levels of protein and energy. For arriving at 300 kg final body weight, calves took 300 days on high protein and high energy ration and 416 days on low protein and low energy ration.

Another experiment[15] was conducted at NDRI, Karnal (India) in which buffalo calves (3 months age) were kept on low and high concentrate diets for 90 days (Table 6), Roughage constituted non-legume forage and skim milk was fed to calves in one of the treatment group kept on low concentrate (50%) diet. However on high concentrate (75%) diet. skim milk was not included. At both the treatments feed intake, daily body weight gain as well as feed conversion efficiency were similar.

Table 6. Influence of low and high concentrate diet on growth

Particulars	Rough : Conc (50:50) + Skim Milk	Rough : Conc (25:75)	't' Value
Body Wt, at 3 months age (Kg)	85.2	84.5	0.07 NS
Body Wt. at 6 months age (Kg)	136.8	138.2	0.09 NS
Daily gain (g)	573	597	0.36 NS
Av. DMI/day (Kg)	2.42	2.69	1.11 NS
Feed Convertion Ratio (DMI/Kg gain)	4.3	4.5	0.75 NS
Cost/Kg gains (Rs.)	40.7	15.1	10.45

($P<0.05$)

In another trial[16] the buffalo calves of the age of 6 months were subjected to growth studies upto the age of 24 months on roughage based diets The diets consisted of rough: conc. ratio 75 : 25 (Group-I) and that of 60 : 40 (Group - II). The DMI/day increased at 12,18 and 24 months of age due to increased body weight. The rate of growth was better upto 18 months, thereafter, it decreased. Feed efficiency (%) was better in group-I which contained less concentrate. The diet of group-I was also cheaper than group-II (Table 7).

In a trial conducted in Italy, buffalo male calves were fed on high energy ration (maize silage *ad lib*, 900 g/day soyabean and 100 g/day Vitamin C mineral supplement) from 6 to 18 months of age. The average daily gain was similar from 6 to 10 and 10 to 14 months (979 g) and at 18 months was (798 g) but was higher than the values reported by Indian workers[17]. The conversion index increased from 10 to 14 months (+18%) and further from 14 to 18 months (+31%) showing lowest productive capacity at this age[18].

Table 7. Body weight gain in buffalo calves at different groups

Age (Months)	B. wt (Kg)	Rough : Conc. (75:25) DMI/d (Kg)	Gains/d (g)	Feed effi. (%)	Rough : Conc. (60:40) B. wt. (Kg)	DMI/d (kg)	Gains/d (g)	Feed effi. (%)
6	146	-	-	-	132	-	-	-
12	246	4.9	555	11.3	231	4.7	551	11.81
18	365	6.8	661	9.70	346	7.2	637	8.80
24	461	8.9	533	6.00	435	8.3	494	9.95

More recently[16] another experiment was conducted at NDRI, Karnal in which growth observations were recorded for 234 days for the calves to reach at veal stage (live wt. 200-250 kg) and for 331 days for the calves to reach at beef stage (live wt. 350-400 kg). One group (Live weight 103.5 kg) was offered ration consisting 80% concentrate with 20% roughage (High concentrate) while the other group (Live-weight 100.0 kg) was fed on a ration consisting 60% concentrate mixture with 40% roughage (Medium concentrate) (Table 8).

Table 8. Productive performance of buffalo calves for veal and beef production

Parameter	Experimental Rations: Group - I High concentrate Conc : Rough (80:20)	Group-II Medium concentrate Conc : Rough (60:40)	('t' Value)
VEAL PRODUCTION			
Initial Body Wt. (Kg)	103.5	100.0	
Final Body Wt. (Kg)	246.0	280.3	
Gain/ day (g)	609	771	4.5*
Total DM intake (Kg)	3.10	4.25	16.5*
Percent Feed Efficiency (Gain kg/100 kg feed intake)	19.64	18.14	2.4
Feed Cost/Calf/day (Rs)	10.28	12.20	8.8*
Feed Cost / Kg BW gain (Rs)	16.88	15.82	
BEEF PRODUCTION			
CONSUMED	75 : 25	61 : 39	
Initial Body Wts (Kg)	107.0	110.0	
Final Body Wt. (Kg)	356.0	377.4	3.5*
Gain/day/calf (g)	752	807	
Total DMI(Kg)	3.90	4.99	12.4*
Percent Feed Efficienty	19.27	16.16	4.8
Feed Cost/Calf/day	13.07	14.38	4.6*
Feed Cost/Kg BW gain (Rs)	17.38	17.81	

Carcass characteristics of buffalo calves at veal and beef stages did not show any variation in protein and total ash content of meat. The fat content in the group-I was higher than in group-II and the colour appearance of meat of both the groups was similar.

EFFECT OF PLANE OF NUTRITION ON GROWTH AND CARCASS CHARACTERISTICS IN BUFFALO CALVES

Very recently an experiment[19] was conducted at CIRB, Hisar. Eighteen buffalo calves (12-13 months, 128-132 kg) were divided into three groups. Control group fed nutrients as per was Kearl (1982) feeding standard and those in groups T-1 and T-2 were fed 15 and 30 percent higher nutrients than control so that their corresponding roughage : concentrate ratio in Control, T-1 and T-2 groups was 75 : 25; 70 : 30 and 60 : 40 , respectively. A special concentrate mixture comprising barley 60, GNC, 10, wheat bran 27, mineral mixture 2 and salt 1 parts, was offered. 4% Urea treated wheat straw and oat silage were offered *ad lib* in all these groups alongwith 5-6 kg green berseem. The growth trial was conducted for 330 days. The average daily gain of calves was 531 , 541 and 566 g in control, T-1 and T-2 groups, respectively. There was increasing trend in body weight gain at higher plane of nutrition, but the differences remaind statistically non-significant (Table 9).

A similar trend was observed for voluntary DM intake and digestibility of various proximate principles however, a reverse trend was observed for CF digestibility. The calves showed a fairly good nitrogen balance in all the experimental groups at beef stage. About 60 percent of the absorbed nitrogen was retained in all the groups studied.

There was an increasing trend in body weight gain in both the treament groups as compared to control, but the differences remained statistically non-significant. The average daily live weight gain during the experimental period of 330 days was 531, 548 and 586 g/h/d in control, T-1 and T-2 groups, respectively. The dressing percentage was 54.70±0.30, 53.80±0.40 and 52.70±0.40 for control, T-1 and T-2 groups, respectively. Similarly, meat quality was almost similar in the three groups. Feed : gain ratio was also similar in these groups studied. The cost of buffalo meat production showed (Table 10) that cost per kg gain under these feeding regimes in the control, T-1 and T-2 groups was Rs. 16.18, 18.21 and 20.02, and their corresponding cost of meat production/kg was Rs. 29.58, 33.83 and 37.99, respectively. It can be inferred from this study that under the Indian conditions the roughage : concentrate ratio above 60 : 40 is not economical and we should formulate the feeding strategy where good quality forage alongwith ammoniated wheat straw can be fed in 75 : 25 (Roughage : Conc) ratio so that the cost of buffalo meat production can compete the world market price.

Table 9. Voluntry DM intake, nitrogen balance and digestibility co-efficients of proximate principles on different planes of nutrition

Parameter	Control Rough : Conc. (75:25)	T-1 Rough : Conc. (70 : 30)	T-2 Rough : Conc. (60 : 40)
DMI Kg/100 Kg BW	2.89±0.03	3.15±0	3.18±0.70
Nitrogen Balance (g/h/d)			
Intake	116.61	128.68	145.16
Faecal-N	31.56	30.8	32.20
Urinary-N	33.11	39.13	42.36
N-retained	+51.94	+59.47	+69.60
Digestibility Co-efficients			
Dry Matter	66.14±0.07	67.61±0.22	71.28±0.90
Organic matter	67.80±0.80	69.20±0.08	71.80±0.07
Crude Fibre	61.31±0.05	59.12±1.11	60.64±0.06
Crude Protein	71.62±0.70	76.64±0.09	77.07±0.80
Ether Extract	80.31±0.20	80.67±0.80	81.25±0.08
Nitrogen Free Extract	72.25+0.70	69.51+0.09	75.14+1.08
Dressing (%)	54.70±0.30	53.80±0.40	52.70±0.40
Meat (%)	68.70±0.40	67.10±0.50	66.90±0.50
Bone (%)	20.00±0.50	22.70±0.60	23.40±0.80
Fat (%)	11.30±0.70	10.20±0.90	9.70±0.90
MEAT : BONE : FAT	6.08 : 1.77 : 1	6.59 : 2.23 : 1	6.89 : 2.41 :1

Table 10. Efficiency and economics of buffalo calves for met production

Particulars	Control		Treatment-I		Treatment-II	
	Quantity consumed (kg)	Cost (Rs)	Quantity consumed (kg)	Cost (Rs)	Quantity consumed (kg)	Cost (Rs)
Concentrate Mixture	504	2016	612	2448	720	2880
Amm. Wheat Straw	330	396	346	45.20	387	427
Berseem Hay	198	158	198	158	198.0	158
Oat Silage	747	299	777	311	804	322
Total Cost of Feeding (Rs)		2869	-	3332.4	-	3787.2
Total Weight gains(Kg)	177.34	-	183	-	189.16	-
DM Consumed (Kg/h)	1779	-	1933	-	2078	-
Feed : Gain Ratio	10:1	-	10:1	-	11:1	-
Cost/kg live wt. gains(Rs)	16.18	-	18.21	-	20.02	-
Total Meat Production (Kg)	97.00	-	98.50	-	99.70	-
Cost of Meat/Kg (Rs)	29.59	-	33.83	-	37.97	-

Note: Cost (Rs/100 Kg) of concentrate mixture, Amm. Wheat Straw, dried berseem and Oat silage was taken as 400, 120, 80, 40 respectively.

FUTURE FEEDING STRATEGIES

About 10-12 million male buffalo calves are born annually in India. Considering a mortality rate of about 10 percent, surviving calves will be about 10 million. About 10 percent of these calves may be retained for draught and breeding purposes for some time but ultimately these animals too will be used for meat production, of course as spent animals. Therefore, if we plan to raise about 10 million calves for meat production economically, we have to formulate feeding strategies based on all forage diet or high energy low protein concentrate to roughage ratio (25 : 75) so that we are able to produce a cheaper buffalo meat in order to fetch better price in the world/Indian market. The strategies may be adopted for economic buffalo meat production.

EDUCATING FARMERS TO RAISE BUFFALO CALVES FOR FATTENING

Balanced feeding : Farmers may be educated to feed male buffalo calves on economical rations so that these calves can fetch better price at veal stage.

Feed all roughage diet : The cost of buffalo meat prodction can be reduced by 50% if calves are reared on legume and non-legume forages round the year. For example in Northern India, green berseem is available in plenty during January to April months and during these months feeding strategy should be planned so that non-legume forage, oat or its silage alongwith green berseem can be fed to these calves *ad lib.* For the month of May to August, berseem hay can be fed alongwith non-legume green fodders and in the subsequent months, September to December, Cowpea/cowpea hay can replace berseem hay.

Finishing ration for starved calves before slaughtering : Most of the buffalo calves (about 1 year) are sold in the marketes of Punjab and Haryana every month. Kharar near Chandigarh has be come one of the biggest market in Northern India where calves are daily brought from villages and they are shifted to Aligarh in U.P. by the middlemen. If these calves are purchased from such markets and are fed for 15-30 days on finishing rations, they can fetch better price and can produce quality meat from these calves.

Consciousness for quality meat : Most of the buffalo meat available in the Indian market is from spent buffaloes which are culled due to one or the other reason. The cost of this meat is cheaper. Meat of the buffaloes reared specially on well balanced fattening ration must get preference over the meat obtained from malnourished calves/old diseased animals. Contrary to this, the buffalo of all kinds is sold at similar rates. It is essential that both producer as well as purchaser must have quality consciousness, so that the producer may get appropriately as per his investment on proper management and feeding of animals. Certain Government nodal agencies may come up to pay incentives to such producers and to watch that the farmers get proper sale price.

Marketing of buffalo meat : Organised market facilities must be provided in a cluster of villages to reduce the involvement of middlemen and reduce transit stress to the animals. There should be some Co-operative agency which should purchase these calves from the farmers and after giving them finishing ration, they can be sold for better price to the owners of big abattoirs available in the region. In addition to this, quality control norms should be framed and followed strictly.

Incentive or subsidy : Dairy farmers in the country may be provided incentive in terms of subsidy and/or loan for the purchase of calf starter, milk replacer, concentrate mixture and green forage. Alternatively, the grown up calves may be purchased by providing the farmers proper price so that producers can enter into enterpreneur to raise the buffalo calves for meat production. Once the market is acquainted with quality product, the subsidy to the producer may be withdrawn and incentive of loan may continue.

Health measures : Animal Husbandry Departments/Dairy Development Corporation in collaboration with meat industry should enforce disease control aspects to the calf producer and hygienic control in the abattoir as well as meat handling factories.

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NUTRITIONAL CHALLENGES FOR EXPLOITING DRAFT POTENTIALITY OF CAMEL

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The history of development of camel is narration of a series of evolution, migration and extinction of interest as well as concern. The occurrence of early evolution of camelidae to be entirely in north America along with surprising spread in the late tertiary age to the south America, and, via Asia to Africa, becoming extinct in North America and recognise dry land ecosystem as habitat.

The dromedary was probably domesticated on the south cost of the Arabian Peninsula in the region of present day Yemen and Oman around 3000 to 4000 years ago and then introduced with the spice trade into North Africa. Today there are about 15 to 16 million dromedaries in Africa, middle east and the Indian sub- continent. The camel production is besieged with rampant adverse climatic conditions and onslaughts of scarcity of feeds and water. This unhorned pseudo ruminant seemed to have accommodated well to the arid and semi- arid regions and in the socio-economic pattern of the pastoral industry.

The outstanding tolerance to the rugged climate and cushioned feet features in combination with peculiar behavioural superiority as keen sense of night navigation rendered this animal since ancient time as most preferential animal in desert. As far as utility of this ungulate in arid desertic tract is concerned, it is referred as excellent means of carrying load, transportation, agriculture and defence services. Beside these, its hide, wool, milk and even meat available as byproduct, additionally contribute for better economy of the rural areas.

However, it is because of their survivability, elasticity, diversity and rewarding remunerative economic value, the density of the camel population is escalating in the desertic countries. India has large camel population and touched 1.45 million in 1990 which is third highest in the world (F.A.O., 1990). Most of Indian camel population is (59.30%) in Rajasthan alone.

If given a chance camels prefer browsing to grazing due to large size of the neck, however, conformation of the lips and teeth help camel to brows and are therefore well adapted as the third story feeders by nibbling tree leaves at height of 12 to 15 feet even on the twigs of the trees which are often spiny. Though camel do not relish grasses but still feed on a wide variety of vegetation including toxic plants such as Subabul (*Leucaena leucocephala*), iron wood (*Erythropheum chlorostachys*) and buck bush (*Gyrostemon australasicus*) etc. responsible for heavy losses in other species[2,3].

Initially the camel nutrition research was taken up at Western Regional Animal Nutrition Research station, Anand, under ICAR project on "Feed and Fodder Survey of Western Region" and at College of Veterinary and Animal Science.

Bikaner under ICAR project entitled "Investigation on Camel Nutrition in Rajasthan Desert" and other studies[4,5,6,7]. Under these projects survey, proximate analysis and digestibility/metabolism studies conducted for common camel feeds showed that due to shrinking vegetation browsing is not sufficient for obtaining enough nutrients to fulfil the requirements. The feed consitute natural flora (tree leaves, shrubs, bushes etc.), products of the desert prone agriculture crops and the byproducts of leguminous crops such as *moth* straw, *guar* phalgati, gram straw etc. (Table 1). Recently with the development in irrigation facility the residue of groundnut crop has become another feed resources for camel. For working camels, supplementation with concentrate such as, Moth, Guar, Gur, Methi and Alum is generally done to meet the nutritional needs as well as to upkeep their body[8].

Table 1. Chemical compostion and digestible nutrients of common camel feeds

	% composition on DM Basis								Digestible Nutrient %				
Feeds	DM	CP	EE	CF	NFE	TA	Ca	P	GE KCal	DCP	TDN	SE	DE
Moth straw (*P. aconitifolus*)	93.40	10.73	1.73	25.19	48.39	14.1	1.0	0.12	3.89	8.69	59.96	-	2.28
Guar straw (*Cymposis tetregonoloba*)	92.46	8.90	1.92	24.15	51.62	13.4	1.3	0.26	3.96	6.22	54.46	-	2.7
Gram straw (*Cicer anteinum*)	94.00	6.51	1.82	23.00	33.55	15.7	2.0	0.28	4.40	3.03	39.50	-	2.6
Pala leaves (*Zizyphus nummularia*)	91.06	13.78	1.74	30.66	44.19	9.6	2.1	0.30	3.84	5.99	51.59	-	2.4
Khejri (*Prosopsis cineraria*)	83.65	22.95	2.91	17.50	43.48	8.0	2.1	0.30	3.91	8.93	48.66	-	1.8
Pardeshi khejri (*P. juliflora*)	95.00	18.43	0.60	14.43	44.33	11.4	2.2	0.25	4.25	9.00	47.00	-	-
Phog (*Calligonum polygoncides*)	94.08	6.50	1.80	30.24	48.94	12.4	3.2	0.42	4.20	4.10	54.42	44.14	-
Bui (*Aurva tomentosa*)	94.20	5.00	0.50	32.14	50.27	10.1	1.6	0.36	4.12	3.36	53.74	14.14	-

Protein protection and supplementation of protected protein with urea could be followed safely and effectively in camels[9,10]. The studies illustrate wide variation in nutrient intake by a relatively uniform population of camels undertaking similar exercise regimes.

The generalized recommendation for nutrient allowances with regards to DCP in particular suitable for raising of young camels with respect to the approximate body weight and to the age could be used in the ration as a thumb rule for practical feeding and formulation of rations[3].

Body weight (Kg)	Age (Year)	DCP requirement (Kg)
350	3.3	0.34
400	3.9	0.47
450	4.6	0.59

Similarly, requirements of metabolizable energy for maintenance (MEn)in adult and pregnant camel have been reported[11]. These were considered to be lower than that of cattle and suggested to reduce further during dehydration. The requirement of energy for maintenance and during last quarter of pregnancy are as under:

Body weight (Kg)	Adult camel (Mcal/day)	Pregnant camel (Mcal/day)
300	7.21	9.6
400	8.94	11.9
500	10.57	14.1
600	12.12	16.1
700	13.61	18.1
800	15.05	22.6

DM intake and body weight gains were lower in a group of camels receiving no concentrate than the group receive high and medium quantity concentrate[12] indicated that supplementation could be used as a tool for exploiting potential of camel. Supplementation of 40% barley as source of energy was superior and most effective to enhance body weight gain[13]. Regarding nutrient utilization in pack camels the experiments were taken up[14] at NRCC on Bikaneri camels with and without water stress and it was observed that camels fed *ad lib* dry fodder of moth chara (*Phaseolus aconitifolius*) with no water stress after completing safari of 950 km in Thar desert during winter and daily sent to 10 km journey with pack load of 100 kg or 2 riders (114 kg) indicated no deficiency problem. The camels maintained their body weight and could cope with work stress. Similarly, camels subjected to water stress by offering water twice weekly, fed same fodder @ 1.33 % DMI providing 0.34 kg DCP and 68.9 MJ ME also did not exhibit any ill effect and camels could go well with this much work and water stress. This suggest that pack animals could be maintained well on leguminous fodders without essentially supplementing concentrate.

Regarding utilization of nutrients and nutrient requirements in racing camels very meagre efforts have been made in the country. However, recently the preliminary studies made in country at National Research Centre on Camel, Bikaner[15], showed increase in DM and water intake during racing period than at rest due to higher nutrient demands of muscular work in racing camels.

A survey[16] was conducted in four large training camps in the U.A.E. for calculating intake of energy and protein. On comparing these intakes with published recommendations for 450 kg camels performing similar exercise regimes, the majority of rations having barley, green alfaalfa, milk, dates, grass, pellets and mixed grain provide adequate energy and excess protein to meet the needs for maintenance and daily 20 km sub maximal training exercise.

270 g of DCP and 49 MJ of ME were recommended[17] as daily maintenance requirement for a 450 Kg camel based on data published for other ruminants. Whereas, recent studies[18] suggested a MEm of 0.31 MJ MEm/kg$W^{0.75}$ compared to 0.50 MJ MEm/Kg$W^{0.75}$ suggested earlier[17]. However, it was also concluded[19] that camels have a daily maintenance requirement of 145 g DCP/Kg$W^{0.75}$ or 142 g DCP for a 450 kg camel at rest.

One of the very important oxygen uptake study[20] on 500 kg racing camels exercised at racing speed of 35 km/h on a treadmill, demonstrated a gross energy use at 100% VO_2 of 0.63 MJ/Min.

So far no information regarding fat requirements for camels is available. However the substitution of rumen undegradable fat sources for conventional carbohydrate has been evaluated in racing camels[21] using iso energic diets. It was found that upto 200 g of protected fat could be substituted for cereal energy sources without metabolic disturbances.

Studies on nutrient intakes of draft camels during rest and load pulling were conducted at NRCC on adult male camels given dry *moth chara* as sole diet. The camels were given pay-load of 2.5 kg/kg body weight by subjecting to two and four wheel carts for 6 hrs continuously. The results suggested increase in DMI, digestibilities of nutrients and nitrogen retention due to the higher nutrient demand for work. The loss of body weight appeared in load pulling animals indicated the need of nutrient supplementation to maintain the camels body weight and work output.

Studies[22] on mineral nutrition of camels reported a negative calcium and phosphorus balance on feeding some feeds and suggested their supplementation. The intake of macro and micro elements decrease with increasing dehydration but their absorption increases. Further studies[23] on mineral requirements of dry, pregnant, lactating and growing camels suggested sodium supplementation in dry, magnesium in pregnant and higher levels of zinc and mangnese in lactating and growing baby camels.

From the foregoing accounts, it could be concluded that requirements suggested for various categories of camels are still need to be updated. The pack and racing camels could be maintained on nutrient supply from leguminous straws with other insufficient conventional natural flora. But the draft camels used for heavy work such as ploughing and pulling load need definite supplementation by including concentrate in their diets to keep them in a fit condition. Attempts should be made to formulate least cost balanced rations with inclusion of non conventional feeds to make the ration effective and economical for working camels.

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MINERAL RESOURCES AND BIO-AVAILABILITY OF MINERALS FOR SUSTAINED ANIMAL PRODUCTION

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Major minerals of nutritional significance are: calcium, phosphorus, magnesium, sodium, potassium, chlorine and sulphur. In addition the trace elements which are essential include: iron, copper, cobalt, manganese, iodine, molybdenum, selenium and zinc. Certain newer trace elements which are gaining nutritional significance of late are: chromium, tin, vanadium, fluorine, silicon, nickel and arsenic. Mineral elements occur as structural components of body organs and tissues as well as constituents of body fluids in the form of electrolytes. In the latter forms, they are involved in functions like maintenance of acid-base balance, osmotic pressure, tissue irritability and permeability of cell membrane. Mineral elements also function as catalysts in enzyme and hormone systems and in several cases they are components of metallo-enzymes.

MINERAL SOURCES

Important sources of minerals include; 1. Plants and herbage 2. Animal products, 3. Mineral supplements 4. Drinking water and 5. Soil and dust contaminating the herbage.

Mineral contents of the plants and herbage are influenced by 1. Genetic differences such as species, strain and variety 2. Nature of soils and application of fertilizers and 3. Plant maturity which is influenced in turn by the season and climate. The categories of feeds of plant origin can be grouped as follows: grasses and pasture, legumes, cereal grains, oil meals, brans, crop residues and tree leaves. The animal products include: meat meal, blood meal, liver meal, fish meal, bone meal, milk and milk products. Among the mineral supplements the chief sources are: natural mineral sources (e.g. lime stone, bone meal etc.) crude or pure inorganic supplements (e.g. common salt, dicalcium phosphate etc.) and chelated mineral sources (e.g. protein chelates, EDTA chelates etc.)

ASSESSMENT OF MINERAL AVAILABILITY

Physiological availability of minerals can be assessed by several tools. Digestibility measurements are not applicable to minerals since faeces is a major excretory route for many minerals from the body. Mineral balance measurement measures net availability or retention. Still it does not reflect fluctuations in the body stores and loss through sweat and exhaled air. In the comparative balance technique net availability of a mineral is expressed as percentage of increase in intake which has resulted in increase in retention. Biologically mineral availability can be usefully assessed by its efficiency in providing amelioration or prevention of deficiency (e.g. Mn supplementation to prevent perosis in chicks). Radio-isotopes are excellent tools of bio-availability assessment of several minerals. They are efficiently used to determine endogenous faecal mineral and true absorption of mineral from the diet. When multiple isotopes of the same mineral are used relative availability of the mineral from different sources can be comparatively measured. By this method it has been observed that Iodine from potassium iodate and di-iodosalycilic acid are available to an extent of 86% to 20% respectively as compared to potassium iodide for thyroxin secretion.

ASSESSMENT OF MINERAL STATUS

To Following approaches are adopted in assessment of the mineral status of the animal:-

1. Soil mineral analysis.
2. Mineral analysis of feeds and fodders.
3. Biochemical analysis of body fluids - such as blood, saliva, urine, faeces etc. for minerals, enzymes and hormones.
4. Tissue concentration of minerals and enzyme activity.
5. Clinical and pathological diagnosis.
6. Correction brought about by supplementation in terms of recovery of health, growth, fertility and productivity.

SOIL MINERAL STATUS

Soil mineral status may be reflected in their status in plants in respect of certain minerals, but not in others. Because, plant mineral status is affected by factors such as yield, genetic differences, chemical form of mineral in the soil, soil pH, degree of aeration and water logging on the land. Plant concentration of minerals is better correlated with dilute acid extracts of minerals from the soil in respect of iodine cobalt etc. However, 'plant available' mineral of the soil is more correlated with plant growth and not necessarily plant concentration regarding several other minerals.

MINERAL STATUS OF FEEDS AND FODDERS

Information on mineral contents of several common pasture grasses, fodders and concentrate feed ingredients is available in literature. Dietary standards are often expressed as ranges of mineral concentrations in feeds recommended against deficiency as well as toxicity. However, any conclusion based on mineral availability based on mineral concentration in the feed may be misleading. Mineral concentration can be influenced by contamination or selective and preferential eating habit of the animal. Further, analytical values do not take into account differences in absorption and utilization of the mineral, their proportion with other minerals or the presence of certain organic compounds which may hamper or help mineral availability. For instance, the presence of phytin as a source of phosphorus greatly limits the bio-availability of phosphorus especially for non-ruminants. Phytin also limits the availability of zinc. Presence of vitamin D greatly influences the calcium and phosphorus utilization in the animal body.

MINERAL ABSORPTION

Mineral availability is greatly influenced by absorption across the gut,. The absorption rate varies widely among the minerals. Calcium absorption is facilitated by its solubility. An acid medium favors absorption. Insoluble tricalcium phosphate in poorly absorbed. Calcium proteinates are assimilated with ease. Factors like oxalates and phytates bind calcium and reduce their absorption. Vitamin D has a great role in calcium absorption and utilization. Phosphorus absorption depends upon a proper calcium-phosphorus ratio. Phosphorus occurring in phytate form is poorly absorbed in simple stomached animals. Magnesium absorption takes place in small and large intestines. In ruminants, magnesium absorption takes place in rumin-reticulum. A lower pH favors magnesium absorption. Potassium, citrate and trans-aconitic acid interfere with magnesium absorption. Absorption of sodium, potassium and chlorine are regulated by concentration gradients. Sulphur in organic form such as sulphur amino acids is readily taken up across the intestinal wall. Iron absorption is greatly regulated by iron status of the animal body. Reduced form of iron is better absorbed which is of significance in non-ruminants. The condition of duodenum influences iron absorption since it is its main site of absorption. Copper, manganese, zinc, cobalt and cadmium interfere with iron absorption by competing for the binding sites in the intestinal mucosa. Dietary calcium interferes with iodine absorption. Excess of sulphur and molybdenum reduces copper absorption. Copper sulphide and copper thio-molybdate are insoluble and are hence not absorbed. Manganese absorption is generally poor in farm livestock and favored by body demand. Calcium, phosphorus, potassium and iron interfere with manganese absorption. Molybdenum is readily absorbed by intestinal tract. Its uptake is checked by copper, sulphur and tungsten. While elemental selenium is insoluble and poorly absorbed selenite, selenate and organic selenium are better absorbed. Zinc absorption is interfered with by high levels of dietary calcium, phytate and copper.

MINERAL STATUS AS REFLECTED BY TISSUE LEVELS AND BODY FLUIDS

Dietary deficiency or excess of a mineral is ultimately reflected in its concentration in certain animal tissues and fluids. It also affects the concentration of particular enzyme, metabolic or organic compound in the animal body. The advantage of assessment of mineral status through its tissue levels and body fluids lies in the fact that the changes in the mineral status can be perceived before the onset of clinical signs of deficiency or toxicity.

Mineral level in blood serum or plasma reflects to some extent the mineral status of the animal. Normal values for blood levels of various minerals are available. Easy accessibility of blood, serum or plasma is an advantage in this method of assessment. However, variations from normal values are only suggestive and not conclusive evidence of deficiency or excess. Individual variations of mineral levels in these fluids are high. Homeostatic mechanism masks the dietary fluctuations, as in the case of sodium and fluorine.

Saliva is most valuable as a definite means of detecting sodium deficiency since saliva is particularly sensitive to dietary deficiency of sodium. Dietary zinc status is also reflected by salivary zinc level. Liver tissue concentration is a valuable means of assessing the status of iron, copper, cobalt or B_{12}. Bone tissue reflects the status of calcium, phosphorus and fluorine in the body. Subnormal urinary sodium points clearly to a dietary deficiency of sodium. Excess of fluorine in urine is suggestive of fluorine toxicity, but it is not confirmatory since it may be due to high excretion from bone due to a previous high intake.

CLINICAL AND PATHOLOGICAL CHANGES

These are diagnostic tools for all mineral deficiencies and toxicities. Several deficiencies and excesses are reflected in specific and characteristic clinical and pathological disturbances. A most common example is thyroid dysfunction in iodine deficiency. Mild deficiencies and excesses are difficult to identify and are indistinguishable from conditions such as energy and protein starvation or intestinal parasitism e.g. cobalt deficiency. Anemia is characteristic of deficiencies of iron, copper and cobalt and is also noticed in molybdenum, selenium and zinc toxicities. Skeletal deformities occur in deficiencies of calcium, phosphorus, copper, manganese and zinc and in excesses of fluorine and molybdenum. Impaired reproductive performance occurs in deficiencies of phosphorus, copper, manganese, zinc, iodine and selenium and in excesses of fluorine and molybdenum. While fluorine has no direct effect on reproduction in enzyootic fluosis, it causes inappitance, deformities of teeth and joints which may affect prehension and mastigation and thereby lead to poor nutrition and poor reproduction. Serum enzymes are good indicators of mineral status in certain cases. For instance, serum aspartic amino transfers rise precedes homiletic crisis in chronic copper poisoning in sheep. Among the serum assays, B_{12} in the case of cobalt, free thyroxin for iodine, ceruloplasmin regarding copper and glutathione peroxides in respect of selenium are most valuable.

CORRECTIVE MEASURES TOWARDS BETTER MINERAL AVAILABILITY

Application of fertilizers and soil amendments can be helpful in certain situations of specific soil mineral disorders. For instance soil treatment of cobalt and selenium makes these elements more available to the animals due to high accumulation in plants though these elements have no direct effect on plant yield. In high alkaline or calcareous soils cobalt application does not result in higher cobalt uptake by plants. Application of sulphur may reduce selenium uptake by plants. But in selenoferous soils high in sulphate or in soils where selenium occurs in organic combinations, application of sulphur to the soil does not result in the desired result. Copper application makes more copper available to plants in low or moderately high molybdenum containing soils, but it is not so effective in soils high in molybdenum levels. High application of nitrogenous fertilizers reduces calcium level in grasses. Potassium application interferes with magnesium and sodium availability to plants. Molybdenum application in deficient soils causes increase in molybdenum availability to plants.

Use of mineral supplements is resorted to as and when the situation is called for. Protein supplementation has been found to increase the availability of calcium, phosphorus, zinc and iodine availability to the animal. Replacement of plant protein by animal protein increases phosphorus and zinc availability in monogastric animals. Specific mineral supplementation is most valuable to egg laying birds, high lactating cows and heavy working horses. In any case, unnecessary mineral supplementation is costly and wasteful. It may be noted that intake of the mineral supplement is more regulated by palatability than by need. Hence, voluntary consumption of a mineral from lick on other supplemental source is not a measure of the need of the mineral. Additional mineral supplementation depends upon the mineral level and proportion in the ration, degree of deficiency and level of production. Supplementation can be made through compounded feeds, mineral licks, water, oral drenching or dosing or by administration of heavy pellets which are retained in the gastro-intestinal tract. Injection of slowly absorbable organic compounds is an effective method too. Salt based mineral licks are most commonly employed for supple menting phosphorus,sodium,iodine,copper,cobalt and molybdenum. Oral dosing of cobalt bullets and selenium and cupric oxide needless is widely practiced. Iron, iodine and copper are administered in the form of injectable organic compounds.

AN UPDATE ON MINERAL BIOAVAILABILITY RESEARCH

Compositional scanning of materials like marble, gypsum, phosphogypsum, chalk powder, lime, plaster of paris, *kharis mitti*, *peeli mitti*, fly ash, kiln dust, rock phosphate ore, Mussourie rock phosphate, super phosphate, filter press mud waste, lime sludge waste and dicalcium phosphate suggested that chalk powder, marble, lime and filter press mud waste could be good calcium supplements because of their high calcium content (above 30%) and low acid insoluble ash content (less than 2%). Rock phosphate and super phosphate could be used as in alternative to dicalcium phosphate[1]. Experiments with chicks indicated that dicalcium phosphate produced from a locally available mineral resource, Mazidagi native rock could be used as a dietary calcium and phosphorus source provided certain harmful elements in the material were eliminated[2]. In an experiment to assess the relative availability of iron from different plant sources and animal sources to chicks, the available iron was found to be highest in sesame seed meal with 96% followed by rice bran 77%, lucerne meal 65% soybean meal 45%, and ground maize 20% in respect of plant sources and poultry by-product meal 68%, meat and bone meal 48%, feather meal 39%, fish meal 32% and blood meal 22%, among the animal sources[3]. Green leguminous fodders and oil cakes are rich sources of cobalt. Maize grain, wheat straw and paddy straw are deficient in cobalt. A level of 0.3 ppm of cobalt has been found to be sufficient for maximum microbial activity while maximum B_{12} vitamin synthesis required still higher levels. 0.3 ppm cobalt resulted in normal serum vitamin B_{12} levels in growing calves. For optimum utilization of NPN for growth, 0.6 ppm of cobalt in the diet would be desirable. Fortification of ruminant diet with cobalt could be used to enhance vitamin B_{12} level in milk[4]. Bioavailability of calcium from four sources of calcium, namely calcium carbonate, calcium citrate, tricalcium phosphate and reduced particle size calcium citrate showed no significant difference in rats[5]. There were significant correlations between bioavailability of phosphorus and solubility in abomasal fluid and 1:100 citric acid solution. Solubility linearly decreased with increasing amounts of partly defluorinated phosphate in the mineral salts[6]. Dietary requirements of copper, cobalt, iron, manganese and zinc were determined for early growing buffalo calves by mineral balance studies as 41.7, 9.14, 650.0, 60.7 and 51.6 ppm, respectively which were found to be higher than the requirements for exotic animals[7]. In a study on solubility of minerals from unconventional mineral resources *in vitro* calcium solubility in ruminal buffer was found to be low at pH 7, but it increased considerably at lower pH. Ruminal solubility of calcium and phosphorus from different supplements, however, were found to have no bearing on post ruminal availability of these minerals[1]. Magnesium bio-availability was lowered by added potassium in the form of potassium chloride in sheep fed wheat straw based diets, either due to changes in ruminal mineral concentrations or fermentation patterns[8]. Incorporation of iodine in the food chain by supplementing mineral mixtures with iodine, 10 mg per kg in households and in food production can overcome iodine deficiency diseases. Deficiencies of zinc and selenium and presence of goiterogens however reduce the bioavailability of iodine and can induce secondary iodine deficiency[9]. Absorption of calcium, iron, zinc and selenium from hydroponically grown wheat flour containing different phytate levels fed to male rates decreased with increasing phytate, but was high at all concentrations due to low mineral density in wheat[10]. In a study on the bioavailability of intrinsic minerals from rapeseed meal, dietary calcium level in pigs increased the absorption and retention of calcium and magnesium. In contrast, addition of calcium carbonate did not influence the apparent absorption and retention of phosphorus, iron, zinc, copper and manganese[11]. In a recent review on assessment of bioavailability of trace elements, usefulness of *in vitro* methods has been discussed. The need for more information on the nature of non-mineral food components and their interaction with minerals has been emphasized[12]. Casein chelates of copper,manganese and zinc chelates of organic legends of vegetable source showed better solubility in ruminal fluid than their ionic counterparts. Ruminal fermentation and nitrogen utilization by microbes were better with these chelates which also caused better energetic efficiency for milk production as compared to the ionic supplementation of these minerals[13]. Lysine bioavailability of copper-lysine and zinc-lysine complexes were estimated to be 89% and 109% of lysine fed otherwise. Relative bioavailability of copper in copper-lysine complex and zinc in zinc-lysine complex were 120% and 106%, respectively of the controls fed these mineral as salts[14]. In growing calves, chelated (EDTA) copper, manganese and zinc supplements proved better than their ionic counterparts as 50% levels of chelates showed similar responses in growth, dry matter intake, blood levels of the minerals and superoxide dimutase activity as 100% fortification levels with ionic forms of these minerals. Chelated forms of these minerals also resulted in better conception among repeat breeders and anaestrous animals[15]. Rats fed on a whey mineral complex containing calcium, phosphorus and magnesium showed higher phosphorus retention than other rats on control[16]. Fructose affects bioavailability of iron,zinc,and cobalt. Fructose forms stable complexes with iron and promotes its absorption and also that of zinc. Fructose and sucrose decrease copper availability in rats while no such effect is noticed in pigs[17]. Dietary fibres may limit mineral bioavailability through ionexchange processes. Maize bran was found to bind sufficient Ca^{++} in the upper gastro-intestinal tract of the pig to impact Ca^{++} absorption to a small extent in certain dietary regimes[18]. Feeding of highly browned casein-glucose products to rats at 5% of the diets produced no effect on iron absorption. No effects were found on stable zinc or copper absorption in 7 men when browned foods were fed compared with same diets without browning[19]. In an experiment to study the effect of dietary zinc on tissue mineral concentration as a measure of zinc bioavailability in chicks bone tissue was found to be the most sensitive to dietary zinc followed by liver and kidney. Diertary zinc had little effect on tissue concentrations of calcium, phosphorus, magnesium, copper, iron or manganese[20]. Liver copper uptake may be useful in bioassays for estimating copper bioavailability from inorganic sources[21].

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FORAGE PRODUCTION AND PROCESSING FOR EFFICIENT UTILIZATION

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The health and productivity of livestock is dependent on the quantity and quality of forage availability in a contry. Balanced and adequate feeding of animals is a major factor responsible for realizing optimum livestock production. The major livestock feed resources are cultivated fodders, nautral grasses, fodder trees and agro-industrial byproducts and crop residues. However, their availability in our country are insufficient of meet the requirements of growing livestock population. India supports 15% of world's livestock population on its 2% of world's geographical area which itself is an indicative of pressure of animals on its limited land resources. The projected livestock population in the country is around 490 million heads (Table 1). The forage available in the country is not commensurate with such a huge livestock population.

Table 1. Livestock population (million) in India over the years[9-10].

Species	1951	1961	1972	1982	1991	1995
Cattle	155.3	175.6	178.3	192.4	198.0	204.0
Buffaloes	43.4	51.2	57.4	69.8	77.0	82.0
Sheep	38.4	40.2	39.9	48.8	58.0	62.0
Goats	47.1	60.2	67.5	95.2	112.0	125.0
Pigs	4.4	5.2	6.9	10.1	10.0	11.0

The present availability is around 550 million tonnes of dry forages from crop residues, pasture and grazing resources and about 370 million tonnes green forages from cultivated fodders, tree fodders, weeds and sugarcane tops. From above resources, a total dry matter of about 643 million tonnes is available in the country. Therefore, availability of forages is only to the extent of 60% of the estimated requirement of forages (Table 2). In another projection[1], assuming the same trend of animal population growth and agricultural crop production, it has been estimated that the deficiency of green fodder will be increased from 25to 32%, while that of dry fodder will be reduced from 40 to 27% by the year 2001 A.D. Thus, the gap between the supply and demand for good quality forage continues owing to constraints like land and resource inputs. At present, only a small fraction of the cultivated are a (6.9 million hectares) is under fodder crops.

Table 2. Estimated fodder requirement (MT) in India by 2000 A.D.[10]

Year	Dry fodder	Green fodder	Total fodder on dry wt. basis
1985	780	932	1013
1990	832	992	1080
1995	890	1064	1156
2000	949	1136	1233

There is also no possibility of any divertion of the agricultural land for fodder crops in near future. But the total area under cultivated fodder crops is about 8.3 million hectares on individual crop basis having a cropping intensity of 120% (Table 3). On the other hand, grazing lands are not only under continuous degradation due to exploitative stress and are shrinking due to competing demand of food and forage under the increasing population pressure, urbanization and industrialization. In future, the farm animals will have to subsist on poor quality crop residues like straw, stovers, etc. and vegetation from wastelands or communal grazing lands. Meeting the demand of quality forages of our livestock is a gigantic and challenge task. However, animal production can be sustained either by improving the productivity of forages or by processing the available forages for their efficient utilizaion. At the same time efforts should be made to bring the available wasteland under forage crops.

Table 3. Area under fodder crops and estimated fodder production in selected states of India[10].

State	Area under fodder crops (1000 ha)	Estimated green fodder production (million tonnes)
Rajasthan	3100	62.0
Gujarat	877	52.6
Madhya Pradesh	876	26.2
Uttar Pradesh	861	34.4
Maharashtra	801	32.0
Punjab	697	48.7
Haryana	683	47.8
Andhra Pradesh	147	4.4
Tamil Nadu	124	4.3
Karnataka	86	3.4
Others	71	3.8
Total	8233	319.9

IMPROVEMENT OF FORAGE PRODUCTION

Forage production can substantially be increased by improving the productivity of forages, from the limited available cropped area through adopting improved forage production technologies as discussed below.

Improved varieties : A large number of improved varieties of forage crops grasses have been evaluated on the basis of higher production potential and better quality traits, adaptability to different agro- ecological zones, suitability to different farming situations etc. (Table 4). After an intensive research work carried out at IGFRI, Jhansi, and the other centres under All India Co-ordinated Research Project on Forage Crops. However, varieties differ in their quality traits. Sorghum variety HC-136 proved to be superior in growth attributes, forage yield and water soluble carbohydrates and HD-2 showed its superiority for drought tolerance, protein content and productivity while cultivar PC-6 had lower HCN contents[2].

Table 4. Some improved var.eties hybrids of forage crops[11] developed/ identified recently at IGFRI, Jhansi

Crops	Varieties/ hybrids	Green forage yield/(t/ha)	Areas of cultivation
Berseem	Wardan	65-70	Whole Country
	JHB-ISB-86	55-70	South zone
	JHB-146	65-80	Central/ North West zones
Cowpea	Bundel lobia-1	25-30	Whole Country
	Bundel lobia-2	25-30	North zone
Guar	Bundel Guar-1	25-35	Whole Country
	Bundel Guar-2	30-40	Whole Country
	IGFRI-1019-1	30-35	Whole Country
Field bean	JLP-3	20-25	Whole Country
	JLP-4	20-25	Whole Country
Oat	JHO-822	44-50	Central zone
	JHO-851	40-50	Whole Country
	Bundel Jai -829	55-60	Hill temperate
Sorghum	J. Sel-4	33-59	Whole Country
	J.Sel-6	35-42	Whole Country
Buffel grass	Bundel Anjan-1	30-35	Whole Country
(Cenchrus)	(IGFRI-3108)		
Dinanath	Bundel dinanath-1	55-60	Whole Country
grass	Bundel dinanath-1	60-65	Whole Country

Intensive forage production system : For milkshed areas with fertile cultivable land and assured irrigation, the intensive forage crop sequences and/or inter cropping systems have been found to be advisable for increasing herbage yield and improving forage quality. An overlapping cropping system of berseem+ mustard and hybrid napier+ cowpea can be followed to supply green forage round the year under Cut and Carry system. This system yielded 286, 240 and 175 t/ ha/ year DM in 1st, 2nd and 3rd year, respectively[3]. This production system provided feed resources adequate to maintain 10-12 milking cows with little or no supplementation of concentrates under appropriate forage conservation techniques.

Integration of forages in arable cropping system : Integration of forages as mixed, inter or rotation crops with the existing food or commerical crops based cropping system, is another potential way to increase the forage yield in irrigated and high input management areas. At IGFRI, Jhansi, berseem+rice suquences resulted in maxium productivity of 67 t/ha green forage and 3.35 t/ha berseem equivalent wheat and 3.09 t/ha rice grain. Moreover, there was saving of 100kg N/ ha at the expense of 20 kg P_2O_5/ ha in berseem-rice rotation as compared to rice-wheat cropping system[4].

Food and fodder systems for dryland areas : Under dryland conditions, to mitigate the shortage of feeds and fodders, the integration of food-fodder production systems through intercropping, ratooning and overseeding grain crops with forage species have been successfully practised. Grass and tree based systems like ley and alley farming found also to be promising in drought prone areas, to increase the overall productivity of small land holdings and strengthen the livestock enterprises as well as conserve land water resources. In monocropped areas, the productivity could also be raised through intercropping of short duration forages in long duration rainy season food crops like grain sorghum and Pigeon peas[5].

Grassland management : The natural grassland of tropical countries including india are poor in herbage yield and quality specially in protein rich legumes. Introduction of pasture legumes like Siratro, Atylosia, Stylosanthes etc. in natural grassland with 20 kg P_2O_5/ha increased the protein content of herbage from 2 to 7%. The association of these lequmes in *Sehima heteropogon* grasslands also increased the dry matter yield and enhanced the organic carbon content of soil[6].

Silvipastoral systems : The alternate land use systems like agroforestry, silvipasture and hortipasture can be practised to increase the forage production in 175 million hactare wastelands. The components of revegetating the huge wastelands include cattle proof trench, clearing of undesirable bushes/trees, land preparation and manuring in strips, introduction of desirable trees and bushes like *Acacia catecheu, Acacia nilotica, Azadirachta indica, Zizyphus* sp., reseeding of perennial range grasses like *Sehima nervosum, Cenchrus ciliaris, Dichanthium annulatum* and legumes like Stylosanthes, Siratro, Atylosia etc. (2-3 kg seed/ ha) in 10 m wide strips across the slopes[5].

Forage production from problem soils/areas : About 7 million hectare of Indian soils are already under excessive salt concentration/sodium activity resulting into lower biomass productivity. Another 6 million hectare is subjected to waterlogging. Grasses alone or in association with suitable legumes offer very good scope of providing nutritious forages for animals besides being used as grazing lands. Different species of grasses like *Brachiaria mutica, Chloris gayana, Leptochloa fusca* and *Setaria sphacelate* etc. have been found to be promising with green yield ranging from 54 to78 t/ha on sodic soils[5].

Table 5. Effect of chopping oat-hay on DMI, rumen parameters and water intake[12]

Particulars	Oat hay		
	Long	Chopped	Ground
DMI (kg/d)	4.31[a]	4.85[a]	5.68[b]
Water intake (L/d)	27.90[a]	24.20[b]	21.20[c]
TVFA (m mol/dl SRL)	7.43[a]	8.73[a]	9.76[c]
NH_3 -N (mg /dl SRL)	20.70[a]	23.30[a]	25.80[b]
Flow rate of liquid digesta (l/d)	100.10[a]	122.60[b]	139.30[b]

PROCESSING OF FORAGES

The productivity of forages from grazing lands and cultivated areas, is high during monsoon months leading to surplus availability of forages during flush period. Similarly, during *rabi* seasons, there is lot of surplus cultivated fodders for 2 to 3 months. During certain periods viz. May-June and October-November the forage supply becomes scarce creating green fodder storage. So, the forage production with its simultaneous processing is extremely necessary for sustaining optimum livestock production throughout the year by way of backing with forage supply continuously.

It is almost universally accepted that the disadvantages of seasonal feed deficits (and surpluses) can be considerably reduced if not completely overcome, by processing and storage during lush seasons utilising in the lean period of fodder availability. The surplus forage available during flush period could be conserved in the form of silage, dehydrated forage, hay, pelleted complete feeds etc. for supporting maintenance and production of animals quantitatively and qualitatively.

Table 6. Losses (DM) during processing of forages into hays[13]

Attributes	Extent of loss (%)
Cutting and conditioning	2-40
Respiration	5-30
Raking and tedding	5-25
Rainfall and damange	10-17
Bailing	3-45
Storage	5-100
Handling and feeding	2-50

Chopping of forages : It is most common and traditional method of cutting the long stemmed green fodder and crop residues into small pieces manually or mechanically before feeding to the livestock. Chopping or reduction in particle size have advantages like easy to handle and feed, avoiding wastage, easy to supplement with other ingredients and check the selective eating by animals, improvement in feed intake and digestion as relatively larger surface area becomes available for microbial activities (Table 5). Traditionally, straws are moistened and mixed with water soaked feed ingredients like oil seed cakes, wheat bran, wheat flour or with compound feed and fed to the animals[6].

Table 7. Nutrient losses during processing of forages into silages[14]

Biological process	Extent of loss(%)
Respiration	1 - 2
Fermentation	1 - 4
Effluent	5 - 7
Secondary fermentation	0 - 5
Aerobic transformation	0 - 10
Aerobic fermentation after unloading	0 - 15
Total processing loss	7 - 35

Hay making : The objective of hay making is to conserve and preserve nutritional value of fresh cut forages by drying it to a level at which the microbial fermentative activity is halted[7]. The fodder crops having soft and pliable stems are more suitable for hay making. However, green berseem, lucerne, cowpear, guar and natural grasses can also be used for hay making. Thin stemmy forages are dried to hay conveniently while thick stemmed require chopping and crushing before they can be dried. The hay can be stored after processing them into bails, wafers, which are a product of densification.

Table 8. Nutritive value of hays[15]

Forages	DCP (%)	TDN (%)	DMI (% of body wt.)
Berseem	10.20	55.3	3.25
Lucerne	10.98	59.0	2.56
Cowpea	8.76	49.9	3.05
Shem	10.39	66.3	3.96
Cilitoria	8.29	57.6	3.30
Guar	5.04	47.2	3.60
Oat	3.41	64.2	3.16
Anjan grass	2.28	46.5	2.44
Oat+ Lucerne(1:1)	7.38	58.3	2.33
Maize+ Cowpea(1:1)	8.08	60.2	2.56

Silage making : Silage is a processed material obtained by controlled fermentation of green fodder crops retaining the high moisture content. Fresh fodders containing desired DM are packed in the silos and allowed to ferment under anaerobic conditions with minium loss of nutrients. Crops rich in soluble carbohydrates are most suitable for silage making viz. maize, sorghum, pearl millet, napier, oat etc. Cultivated and natural grasses have also been found to be excellent materials for silage preparation. This might be a profitable method by which about 220 million tonnes of surplus green foliage derived from inaccessible and semi-inaccessible areas of the forest during monsoon can be utilised when hay making is not possible[8].

Legume fodder crops after wilting to 30% dry matter and mixed with dry forages may be ensiled. However, the nutritive value of processed forages depend upon to the great extent on the nutrient contents of the original forage and also the loss of nutrients resulted from processing into hay (Table 6) and silage (Table 7). The nutritive value of some common forages after processing them into hay or silage have been depicted in Tables 8 and 9, respectively.

Table 9. Nutritive value of silages[14]

Forages	Ratio	DM(%)	DCP(%)	TDN(%)	DMI(%)
Hybrid Napier(NB-21)	-	51.5	0.9	54.4	2.67
Maize+Cowpea	1:1	69.4	8.4	64.1	2.86
Berseem +Oat	1:1	51.8	6.7	56.4	2.88
Maize+Anjan grass	3:1	46.3	1.8	43.7	1.97
Lucerne+Wheat Straw	2:1	53.1	5.1	50.9	2.95
Berseem+Paddy straw	1:5	47.6	3.0	46.2	2.42
Berseem+Grass	1:5	52.6	0.4	54.4	2.37
Berseem+Sorghum straw	01:5	59.5	3.8	56.4	2.56

COMPOUNDING OF FEEDS

Feeding of complete ration to animals is a departure from conventional feeding practice whereas individual ingredients of ration are fed sepreately. It involves feeding of mixed diets based on variety of available ingredients. Processing of complete feeds comprising of forages, concentrates and other feed supplements in the required proportion into uniform mixture enables the animals to eat sufficient feed and thus will ensure the supply of balanced nutrients. This innovative approach towards feeding of animals, ensures better consumption with desired forage-concentrate ratio and avoid refusal of even different unpalatable ingredients. Complete feeds are formulated and processed into either mash or pelleted form which includes grinding, mixing, steaming, pressing and extruding.

Table 10. Effect of different complete feeds on feed intake nutrient digestibility and milk yield in lactating cows[16]

Particulars	Control (Conc. + Hy. napier)	Complete feed	
		Mash	Pellets
Feed intake (kg/d)	11.59[a]	14.86[b]	15.97[b]
Milk yield (kg/d)	8.09	8.69[b]	8.80[b]
Intake kg milk (kg)	1.43	1.70	1.81
Nutrient digestibility (%)			
DM	61.8	62.6	62.1
CP	59.8[a]	65.7[b]	71.8[c]
EE	60.3[a]	62.2[ab]	66.9[b]
CF	66.1[a]	56.9[b]	55.4[b]

This processing results into increased voluntary intake and nutrient digestibilities, reduction of wastage and improvement in efficiency of utilisation of nutrients (Table 10). Thus, processing of complete feeds utilising locally available crops will go a long way in utilising existing feed resources more efficiently for economical animal production in view of chronic feed deficits, increase in the prices of feed ingredients and changing cropping patterns.

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UTILIZATION OF NON CONVENTIONAL FEED RESOURCES FOR SMALL RUMINANT PRODUCTION

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Sheep and goat rearing is traditional occupation of marginal farmers, landless labourers and nomads in the regions of the country wherein conventional crop production is a gamble due to prevailing unfavorable agroclimatic conditions. The small ruminants are usually maintained employing self or family labour under extensive range management on degraded public range land, forest land and stubble grazing on cropped land after harvesting. The farmers also extensively use top feed resources for sustaining their stock during critical lean season. In spite of tapping all the feed resources available in their locality, the farmers from Western zone of the country resort to short and long distances, even inter state migration with their stock during lean summer season seeking greener pastures. Similarly, Gaddis and Bakerwals from foot hills of Himalaya migrate to high altitude alpine pastures during lean summer months of the plains to utilize available lush vegetation there and return back to their native tracts in favourable season.

Although India is endowed with large sheep (44 m) and goat (105 m) population (FAO 1992) with 40 sheep and 20 descript goat breeds (Acharya 1982), yet their production figures do not commensurate with their population. The reasons ascribed to such low production are indiscriminate breeding and intermixing of breeds, inadequate feed resource, livestock stocking rate far exceeding the carrying capacity of the land, traditional husbandry practices, inadequate health coverage and above all lack of remunerative prices due to unorganized marketing structure. Table 1 shows the distribution of sheep and goats in different states in india.

Under the scenario of increasing livestock population and concomitant shrinkage of grazing land, it is becoming inreasingly difficult to maintain small ruminants on extensive range management alone. Hence to bridge the gap of demand and supply of feed resources, non conventional feeds and tree leaves are being widely used to meet the requirement of small ruminants. To meet the future challenges, intensive system of feeding management have been developed by concerted efforts. The objective of the paper is to explore use of non-conventional feed resources in small ruminant production in the country as well as to identify thrust areas of future research in the changing scenario.

FEED RESOURCES FOR SMALL RUMINANTS

The total area available for livestock grazing accounts for about 40 % geographical area of the country and in eight states more than 50 % of land mass is used for grazing, whereas, in states like Himacmal Pradesh, Jammu and Kashmir, Meghalaya, Nagaland and Arunachal Pradesh more than 70 % of the land is used for livestock grazing (Tyagi and Singh 1988). In addition the country has about 67.3 m ha forest land containing ground vegetation, browse species and lopped and fallen top feeds which serve as important source of biomass for small ruminants. The lush vegetation in alpine ranges of Himalayas although inaccessible to large ruminants is effectively utilized by sheep and goats during summer migration.

Table 1. Sheep and goat population in different states of India (in millions)

State	Sheep	% of total population	Goats	% of total population
Andhra Pradesh	6.872	14.92	4.876	17.73
Arunachal Pradesh	–	–	0.108	-
Assam	0.067	0.15	2.134	1.94
Bihar	1.529	3.34	15.032	13.64
Goa	–	–	0.018	0.02
Gujrat	1.569	3.41	3.585	3.25
Haryana	0.890	1.94	0.674	0.61
Himchal Pradesh	1.112	2.43	1.120	1.02
Jammu & Kashmir	2.493	5.45	1.396	1.27
Karnataka	4.727	9.35	3.888	3.53
Kerala	0.030	0.06	1.581	1.43
Madhya Pradesh	0.834	1.82	7.751	7.03
Maharastra	2.872	6.82	9.191	8.34
Manipur	0.016	0.03	0.044	0.04
Meghalaya	0.015	0.03	0.194	0.18
Mizram	–	–	0.020	0.02
Nagaland	0.001	–	0.072	0.07
Orissa	1.840	4.02	4.804	4.36
Punjab	0.508	1.11	0.537	0.49
Rajasthan	9.933	21.73	12.577	11.41
Sikkim	0.011	0.02	0.098	0.09
Tamil Nadu	5.881	12.86	5.921	5.37
Tripura	0.003	–	0.441	0.40
Uttar Pradesh	2.181	4.77	11.321	10.27
West Bengal	2.312	5.05	22.695	20.59

Adapted from Patnayak and Karim (1994)

Biomass yield of tropical grass land varies from 2 to 10 T/ha/year (Leith 1975) and according to grass land survey of India *Sehima- Dicanthium and Dicanthium -Cenchrus -Lasiurus* grass covers have dry forage yield ranging from 1.0 to 3.5 and 1.5 to 6.0 T/ha/year while unprotected public rangeland have yield of 0.5 to 0.9 which would increase to 2.2 to3.2 T/ha/year with protection alone (Kanodia 1994). The arid range land of western India has average dry forage yield of 0.3 to 1.6 T/ha/year (Ahuja 1980) which would increase to 3.3 to 5.0 T/ha/year with protection alone(Dabadghao and Shankernarayan 1973). Dry forage yield can be substantially increased under silvipastoral system having potential up to 5.7 to 7.9 T/ha/year (Debroy et al. 1978). Incorporation of fodder trees/shrubs having multifacet utility on the grazing land substantially adds to feed resource availability during dry lean season besides helping in eco-conservation. It is also a fact that in critical zones of the country, roughly 60 % of feed requirement for small ruminants with farmers is met from top feed resources (Singh 1981). The informations on top feed resources in the country and its contribution in sheep and goat production have been extensively covered in the compilation edited by Singh (1983).

Forest survey of India inventory indicate that all forest land in Rajasthan is subjected to grazing whereas in UP, West Bengal, Sikkim and Nagaland the respective figures are 33, 70, 75 and 53 % (Tyagi and Singh 1988). Excessive grazing on forest land will disturb its ecosystem by hampering natural regeneration. Contrarily, the fallen biomass of the forest if not utilised by the animals will be washed away in natural cycles without serving any purpose. About 300 to 350 m MT of dry fallen leaves and grasses are available from the forest which is almost equal to total crop residues production of the country (Punj 1983). Judicious and scientific use of the resource will substantially ease out problem of ruminant feed resource shortage in the country. Further 50 % of the biomass consumed by the animals is recycled back to the forest surface in the form of biologically enriched faecal pellets serving as organic fertilizer.

SHEEP AND GOAT PRODUCTION STATUS

The birth, weaning, 6 months, 9 months, 12 months and adult male and female weights of Indian sheep ranged from 2.0-3.5, 7.6-13.7, 9.3-20.9, 14.5-21.1, 13.6-28.0, 29.7-50.0 and 19.7-44.5 kg and that of goats 1.6-4.3, 5.8-12.1, 7.8-15.6, 9.2-24.0, 11.8-29.6, 20.4-59.8 and 19.7-44.5 kg, respectively in different reports (Acharya 1982). However the corresponding weights of small sized Black Bengal goats are 1.3, 6.1, 7.4, 8.8, 12.6, 32.4 and 20.4 kg. Mortality rate in adult stock raised under farmer's management ranged from 4.8-26.0 % while those of lambs 12.3-47.0 %. The reproductive efficiency of sheep varies widely in field conditions particularly in north India ranging from 39.6 to 130 % in different breeds whereas it is generally higher for Southern breeds (75.2-85.0 %).

Sheep population of the country contribute 43 m kg wool, 153 m kg meat, 25 m kg milk and 87 m kg skin while the goats contribute 410 m kg meat, 1900 m kg milk (3 % total milk production), 100 m kg skin and 0.03 m kg pasmina to the GNP. The sheep contribute approximately Rs.800 annually to the national income alongwith foreign exchange earning of Rs.1236 crores through export of carpets and Rs.282 crores through export of hosiery and other woolen products. Similarly, the goats contribute Rs.152 to national economy through production of meat, milk, skin and Pashmina.

GRAZING BEHAVIOUR OF SHEEP AND GOATS

In mixed grazing, goats act as leaders and the sheep as the meek followers. Because of differences in their grazing behavior the goats move with their head up and the sheep keep their head down. The goats cover longer distance and have tendency to scatter in the field. They have wider choice of feed, discrening taste sensation and ability to distinguish between bitter, sweet, salty and sour taste with greater tolerance for bitter substances (Devendra and Mc Leroy 1982). Goats unlike sheep prefer browse plants and 90- 98 % of their feeding time is spent on browsing (Acharya *et al.* 1980; Carew *et al.* 1980). These studies (Tables 2 and 3) indicate that in mixed grazing, goats have better chance of collecting food from pasture than sheep and cattle and therefore it can be safely inferred that nature has provided *short grasses for sheep, tall grasses for cattle and buffaloes and bushes, shrubs and* trees for goat browsing (Singh 1981).

Table 2. Performance of sheep under different feeding management

Grazing system	Breed	Birth wt. (kg)	Weaning wt.(kg)	6 m wt. (kg)	12 m wt. (kg)	Reference
Public range land	Malpura	2.8	9.4	15.8	-	Kaushish *et al.* (1990)
Protected	Malpura	2.6	8.6	12.5	13.7	Acharya (1980)
range land (semi arid)	Nali	-	7.6	9.3	13.6	
Protected	Year -1	3.3	11.3	19.4	-	Patnayak *et al.* (1993)
range land	-2	3.3	9.9	13.3	-	Patnayak *et al.*(1994)
Farmer managed						
protected	Marwari					
range land	Year -1	2.9	13.6	18.4	20.9	Patnayak *et al.* (1988)
(Arid)	-2	3.2	10.3	17.1	24.3	
	-3	2.8	10.1	12.8	-	
Cenchrus pasture	Avimans					
Silvi pasture	Avivastra	3.2	13.8	20.6	23.9	Singh *et al.* (1985)
		3.1	12.8	21.9	-	Sankhyan *et al.* (1993)
Grazing with	13 breeds					
supplementation		2.7	10.9	15.5	21.4	Patnayak *et al.* (1995)
Intensive	Malpura	2.6	17.2	30.8	-	Karim & Rawat (1997)
feeding	Sonadi	2.5	13.9	24.6	-	
Mutton	synthetic	3.0	18.0	33.4	-	

Nutrition of small ruminants on range land solely depend on their ability to gather food which in turn is governed by day length, environmental conditions and availability of forage on the pasture. Generally, with reduction in biomass availability, the animals in pasture spend more time in grazing to satisfy their DM requirement as the intake per bite decrease significantly. The interrelationship between grazing time and bite per minute or amount per bite vary with physical structure of the forage, its bulk density and height.

Table 3. Performance of goat under different feeding management

Feeeding regimen	Breed	Birth wt. (kg).	Weaning wt. (kg).	6 month wt. (kg).	Reference
Grazing/browsing	Sirohi Marwari Kutchi	3.0	12.8	19.3	Singh (1993)
Grazing with supplementation	-do-	3.2	14.9	24.5	-do-
Grazing alone	Sirohi	2.8	14.6	20.9	Singh (1995)
Browsing	Sirohi	-	12.0	13.8	Parthasarathy *et al.* (1984)
Browsing with green fodder	-do-	-	11.0	14.8	-do-
Browsing with GN cake	-do-	-	12.7	22.5	-do-
Browsing, conc. and green	-do-	-	12.6	22.4	-do-
Silvi pasture	Marwari	-	12.8	21.5	Sankhyan *et al.* (1996)
Grazing with conc. @ 1.5 % B.Wt.	-do-	-	17.5	26.2	Shinde *et al.* (1995)
Grazing with conc. 150 g/day	-do-	2.9	16.7	21.9	Singh (1995)
300 g/day	-do-	3.1	17.3	22.4	-do-
450 g/day	-do-	3.2	19.1	23.0	-do-
Intensive feeding	-do-	-	15.7	26.9	Mehta & Khan (1995)
-do- Kutchi	-	14.3	24.0	-do-	
-do- Marwari	-	17.2	23.0		Shinde *et al.* (1995)

Animals in the field exhibit two primary grazing periods i.e. early morning and late afternoon whereas rest of the period is usually devoted to idling including rumination. Sheep and goats maintained on degraded range land indicated that the two species spent 8.33 and 8.43 hours in fields while their effective grazing period was 3.48 (44.4%) and 4.39 (53.3%) hours respectively (Swain 1982). Animals grazed on such pasture need longer grazing hours during summer months to meet their nutrient requirement (Singh 1986). However inclement weather of the region does not allow the animals to spend more hours of grazing owing to high environmental temperature and hot sunny days (Bond *et al.* 1984). With increase in ambient temperature from December to March the grazing period decreased from 8.3 to 7.7 hours (Shinde *et al.* 1997).

FEEDING MANAGEMENT PRACTICES

The linear increase in goat population in semi arid and arid regions is ascribed to their wider choice of vegetation (Karim and Shinde 1993), better nutrient utilization ability (Bohra 1980) and adaptability to hot agroclimatic conditions (Karim 1985). Extensively, the range management is the dominant production system in the country whereas in view of likely changes in land utilization pattern in the country, extensive work has been conducted on degraded range land, improved pasture, mono culture grass pasture, mixed grass and legume pasture and two and three tier silvipasture assessing their carrying capacity as well as the production profiles (Acharya *et al.*1980; Patnayak and Karim 1994a; Patnayak and Karim 1994b; Patnayak *et al.* 1995). Similarly, concerted research spread over two decades on evolving intensive feeding system in sheep and goats have generated voluminous data indicating its ready application in the farmers field (Karim 1995). In addition, a large number of sheep and goats are raised in villages and mostly in cities under cut and carry system of feeding management. The animals in this system are fancy fed for customary occasions and hence has comparatively lower significance in national prospective.

NON CONVENTIONAL FEEDS FOR SMALL RUMINANTS

Top feed resources : In some regions of the country probably more animals are maintained on top feeds than the conventional fodder resources. The trees and shrubs of different agroclimatic zones having significance in small ruminant feeding are detailed in Top Feed Resources edited by Manohar Singh (1983) The tree leaves are best utilised in browsing by sheep and goats. Additionally, in semi arid and arid regions of the country tree leaves are harvested and sun dried at appropriate stage and time for use as supplements in addition to grazing during lean summer months. However browsing by the animals on the bushes or freshly lopped trees is nutritionally advantageous as well as economic.

The dry matter content of the top feed ranges from 20 to 40 % with 10 to 15 % CP on DM basis (Singh 1982) whereas higher CP value (20 to 23 %) has been reported for Subabul (*Leucaena leucocephala*) leaves (Upadhyaya *et al.* 1974). The ether extract fraction is high with low crude fibre content whereas the fibre fraction gets complex and lignified at maturity with concomitant decrease in CP content (Singh 1981). The calcium content is generally 2 to 3 times higher than the conventional fodders with low phosphorus content resulting in wide Ca to P ratio. Higher Ca content of top feed has little advantage without F supplementation (Singh 1982). The palatability, digestibility and nutritive value of the tree leaves also decreases with advancing maturity (Negi 1977).

Agricultural byproducts : Indian livestock are primarily maintained on crop residues and other poor quality roughages and forages. The crop residues available in the country are rice and wheat straw, stovers of sorghum, millets and maize and sugar cane bagasse. These materials are invariably low in protein but highly fibrous and have low digestible energy and protein. Methods have been developed to improve their utilization by chemical and microbial treatments with variable success. The most successful and cost effective among these methods is ammoniation of low grade roughage using urea treatment. A sizable quantity of straws, stovers and other byproducts are still not effectively utilized by the animals due to lack of information on their accurate estimates and identification of regions surplus and deficient in these resources and unorganized transport facility and fodder banks to meet the emergencies.

Although wide variety of agricultural byproducts have been screened for their use in livestock feeding (Punj 1995) still very few of them have significance for small ruminants. The crop residues having relevance in sheep and goats feeding are jowar, bajra and maize stovers, wheat and paddy straw, groundnut straw, pulse straws, sunflower tops and straw etc. Similarly, groundnut, mustard, *til* and cotton seed cakes after oil extraction and pulse *chunnies* have been conventionally used in sheep and goat feeding depending on the abundance of the material in different agroclimatic zones. It is however realized that supplementation of these byproducts to small ruminants during critical physiological stages and the seasons is not widely practiced due to lack of these resources at sheep farmers disposal and poor economic back ground of the farmers. Studies conducted at CSWRI, indicated that urea treated *bajra kadbi* and Baru (*Sorghum helipense*) with 6 g Na_2SO_4 can maintain the adult sheep (CSWRI 1992).

Agricultural waste materials: Since the farmers engaged in sheep and goat raising belong to weaker sections of the society, this group of feedstuffs have real importance in meeting their requirements. Mustard straw (MS), a byproduct of widely cultivated mustard crop in semi arid and arid regions of the country, is usually burnt or left in the field to decay naturally without serving any practical purpose rather adding to environmental pollution. The MS as such is not accepted by the animals due to its hard consistency and high glucosinolate content (Tyagi *et al.* 1997). Urea treatment of MS followed by ensiling changes its physical nature and improves *in vitro* digestibility (Mishra *et al.* 1996) as well as utilization by the sheep (Misra *et al.* 1992 ; Misra *et al.* 1995). The MS as such or urea treated alone can not maintain the sheep whereas in combination with 200 g concentrate can sustain them during scarcity (Misra *et al.* 1992). However under farmers level concentrate feeding is not feasible due to his poor socioeconomic status. Therefore, maintenance of sheep on all roughage diet utilizing urea treated MS in combination with tree leaves in 25:75 ratio will be viable alternative (Misra *et al.* 1996).

Prickly pear cactus (*Opuntia* spp.), a fast growing xerophytic plant well adapted to semi arid conditions, rich in energy and water and poor in protein, has been used in livestock feeding in North America since 19th century (NRC 1976). The plant is extremely variable in nutritional value depending upon species, variety, age of the plant, sampling season and plant parts. However, in general *Opuntia* is high in moisture (85 %) and IVDMD (75%) and can be used as source of sustenance in drought feeding (Hanselka and Paschal 1990 ; Sirohi *et al.* 1997). *Propis juliflora*, a leguminous plant well adapted to semi arid and arid ecology having multi facet utility yielding 17 to 140 kg pod having high CP and energy value can replace 30 % of concentrate in ruminant feeding (Shukla *et al.* 1991). Similarly, babool (*Acacia nilotica*) pods @ 150 g/day with *ad lib.* cenchrus hay could maintain the pregnant ewes in positive N balance (Sehgal and Gopal 1991). Studies on Siris (*Albezia lebbeck*) pods indicated that the ground material can replace 20 to 40 % concentrate for adult sheep (Ratan 1994). Similarly, cotton straw, cotton seed hulls, groundnut hulls, sunflower straw, sunflower heads, sugarcane bagasse, saw dust, wood pulp waste, forest dry grass and leaves have been used in small ruminant feeding at appropriate level of incorporation (Reddy, 1886, 1988; Reddy and Reddy 1992)

Lopping of standing trees in forest is prohibited. However, the forest department do not object to removal of dry fallen leaves from the surface. Punj (1983) estimated that 300 to 350 m MT dry fallen leaves and grass is available from the forest with nutrient content particularly CP value better than the crop residues like paddy and wheat straws. It was estimated by Reddy (1989) that about 43 m MT of the resource, if processed, can be effectively used in livestock feeding. The ground tree leaves can be incorporated in various feed formulation at apropriate levels for maintenance of sheep (Reddy and Reddy 1984, 1986) and even for growth providing ADG of 180 to 200 g (Karim 1995). Fallen tree leaves however can not maintain sheep on sole feeding owing to their low palatability and nutritive value (Reddy *et al.* 1984). However, the major constraint in its utilization is the collection of the material since free grazing is objected by the forest officers as the process will hamper natural regeneration of forest cover. Further small ruminants, particularly goats have been blamed for degradation of forest cover due to their bipedal stance whereas it is realised that higher stocking density with cattle will have similar consequences.

LIMITING FACTORS IN NON CONVENTIONAL FEED RESOURCES

The toxic factors can be classified into three broad groups viz. the substances limiting digestion and metabolism of proteins, reducing solubility and utilization of minerals, increasing requirement of certain vitamins and hormones, cyanogens, nitrate and nitrite and mycotoxins. The toxic factors having significance in small ruminant feeding are ricin, saponins, tannins, phytate and oxalate, glucosinolates, gossypol, mimosin, cyanogens and certain mycotoxins. Various treatments such as water soaking and washing, urea and alkali treatment, supplementation of chemical compounds have been developed for annulment of these factors. However in view of socio-economic status of farmers these methods have little significance hence their tradional method of dilution is of practical use.

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EMERGING TENDS IN FEED PROCESSING AND THEIR IMPACT ON ANIMAL PRODUCTIVITY

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Concentrates and roughages are subjected to various processing methods before being offered to the animals. The major aims of feed processing include bringing all ingredients in to a homogenous and uniform mix to have a desirable nutrient concentration, to prevent selection of more nutritive parts by animals, to improve palatability of the feed and therefore the intake and digestibility. Various special techniques of processing such as extrusion, expansion, pelletisation etc. are aimed, in addition, at improving the digestibility and utilisation of feeds and to destroy antinutritional factors present in such feedstuffs. In addition, fibrous roughages including crop residues and other agro-industrial by-products are subjected to various physical and chemical treatments for improving their palatability, intake and utilisation by farm livestock. Keeping in view the prevailing feed resource base and the background information various emerging trends in the frontier area of feed processing and their impact on animal productivity are discussed.

PROCESSING OF ROUGHAGES

Roughages are subjected to various processing methods such as chaffing, grinding, pelleting, chemical treatment and their incorporation into complete feeds with the aim of improving palatability, intake, utilisation and thereby productivity performance of animals.

Chaffing is a less severe processing method and aimed at preventing selection of highly nutritive tender parts by animals and also to prevent feed wastage. The stemmy and fibrous nature of crop residues makes it imperative to process them for size reduction for their improved intake and utilisation. The bulk density increases markedly by grinding and further improved by pelleting. The increase in density on grinding was due to decreased particle size, which reduces their cost of transportation. Grinding increased the density of cotton seed hulls by 32 % and 88 % with Sehima dry grass. Pelleting of ground materials increased the density by 54 per cent in maize cobs and 236 per cent in maize straw[1]. There will be marginal improvement of dry matter (DMI) intake by grinding but a marked improvement can be attained by pelleting of the ground material. Pelleting markedly increased the digestibility of NDF, ADF, hemicellulose and cellulose of many crop residues[1]. Grinding did not improve the digestibility of fibre fractions of crop residues and forest grasses but there was a slight decrease in the digestibility of these nutrients due to grinding as compared to chopping. This might be due to fast passage from reticulo rumen. Pelleting improved markedly the nutritive value in terms of DCP and TDN of crop residues and forest grasses as compared to chopping and grinding. Grinding, however, did not improve the nutritive value.

Complete feeds : This is particularly relevant for utilisation of agro industrial by-products and non conventional feed resources (NCFR). In this system, all the feed ingredients inclusive of roughages are processed and mixed into an uniform blend that discourage selection[2]. These complete rations provide adequate and balanced nutrients in an optimum ratio of concentrate and roughage. More than sixty complete diets have been formulated and produced at this University in the past decade using locally available agro-industrial by-products, NCFR and forest grasses. These studies indicate that fibrous crop residues can successfully be used as the sole source of roughage in complete feeds for optimum growth and milk production when processed suitably.

CHEMICAL TREATMENT OF INFERIOR QUALITY ROUGHAGES

There is considerable opportunity to increase the utilization of crop residues as animal feeds. Various chemicals have been tried to improve the DM digestibility and feed intake of low quality roughages and has been reviewed for comparison of percentage improvement[3]. Feeding systems based on crop residue based rations and the relative merits of various physical, chemical and biological treatments attempted under Indian context has been thoroughly reviewed[4].

Alkali treatment : Use of strong alkalies such as NaOH for treating straws has shown to improve the digestibility of cellulose and hemicellulose components. Based on the studies carried out with barley straw, mixtures of calcium hydroxide and urea were proved to be the alternative chemicals to NaOH or ammonia for improvement of the nutritive value of the straws[5]. Earlier studies showed that treating with calcium hydroxide alone resulted in mould growth. Both NaOH and heat treatment modified alfalfa protein into a less soluble and more slowly degradable feedstuff in the rumen but heat tretment showed greater effects than the NaOH treatment[6].

Urea-ammoniation of straws : Urea-ammoniation of straws increases their N content and utilisation. The true OM digestibility tended to be slightly greater with urea-ammonia treated straw compared to untreated straw[7]. Total N reaching the intestines will be greater with treated straw diets. Cows devoted more time with increased jaw movements for eating untreated straw than for eating treated straw.

Effect of ammonia and/or sulphur dioxide : Chemical treatment of straws and other crop residues has the objective of increasing the DM digestibility for ruminants and can be accomplished through the use of either alkaline compounds[8] or oxidising compounds[9]. The mode of action of alkaline compounds consists of partial hydrolysis of the cell wall, with the rupturing of ester bonds between hemicellulose and lignin without removing the later. Oxidising agents such as sulphur dioxide seem to cause a complete solubilisation of hemicellulose and a reduction of lignin content of the treated material, possibly creating hollow spaces within the cellulose matrix that makes the cell-wall more accessible to ruminal microbial action.

Enzyme treatment of straws : The use of enzymes for upgrading straw has not been studied extensively. The main advantages of enzymic methods are claimed to be much greater control on the endproducts formed after treatment and little or no potential environmental pollution[10]. The two main approaches to the use of enzymes recently examined have been related to the use of polysacharidases and ligninase enzymes. It is clear that much work is required on the use of enzymes for enhancing the energy values of straws.

Biological degradation of fibrous feeds : Rumen microorganisms do not possess enzyme systems for break down of lignin Lignin also prevents the utilisation of other structural carbohydrates such as cellulose and hemicellulose which are associated with it in the plant cell-wall. Thus, a substantial portion of the energy of crop residues is unavailable to ruminants. It has been found that the white rot fungi have the capacity to attack lignin polymers, and to open aromatic rings to release low molecular weight fragments[11]. The two - stage Karnal process developed for biological treatment of straws involved treatment of straw with urea during the 1st stage for 25 d followed by inoculation with *Coprinus fimetarius* spawn for a period of 5 d[12]. Application of urea during the first stage resulted in breaking of ligno-cellulosic bonds besides providing a conducive alkaline pH for inhibiting the growth of undesirable microorganisms favouring the growth of inoculated fungus. Increase in amino acid levels in the fungal treated straw over untreated or urea treated straw indicated that the fungus is capable of utilising ammonia generated during the first stage for synthesizing amino acids during the second stage. Subsequently the process was further refined[13]. In the modified method, the straw was first treated with anhydrous ammonia instead of urea and treatment period was reduced from 30 to 7 d during the first stage. This was followed by a 5 d period for the activity of fungal inoculation during the second stage. The increase in the protein and amino acid contents was of the same magnitude inspite of the fact that the modified process involved only 12 d and is therefore much faster without in any way adversely affecting the nutritive value of the straw.

Fungal treated straw contained higher protein compared to urea treated straw but the fungal treated straw showed reduced DM digestibility with lower TDN value compared to urea treated straw[14]. A combination of 4 % NaOH treatment plus 1 h steaming before inoculation with *Aspergillus terreus* A_2 gave maximum increase in CP content (19.86 %) in submerged fermentation under laboratory conditions[15]. Wheat straw was treated first with the fungus *Coprinus fimetarius* and then with the nitrogen fixing bacteria *Azobacter chroococcum* for a week followed by urea treatment in the second stage[16]. There was increase in CP content from 3.75 to 16.1% and digestibility of DM from 47.1 to 53.0 % Steaming of wheat straw for 30 min. before inoculation with *Pleurotus ostreatus* caused maximum improvement in the nutritive value of straw.

PROCESSING OF CONCENTRATES

A variety of methods such as steam flaking and rolling are used for processing grains. The major aim of processing is to increase energy availability. In addition, processing may destroy mycotoxins and improve mixing characteristics of grains thereby improving the performance of the animals. The importance of role of processing in affecting the nutritive value of several grains as energy sources has been reviewed[17].

Cereal grains are subjected to various heat treatment techniques such as roasting, flaking, rolling etc. with the aim of increasing the efficiency of utilisation and thereby improving the animal performance. Recent studies indicate that flame roasting of barley, corn, oats and wheat had little effect on their utilisation by non-*ruminants but significantly decreased the effective ruminal degradation of DM and* CP[18]. It was suggested that heat treatment by roasting may be beneficial resulting in a slower release of nutrients in the rumen and allowing more DM and CP to escape rumen degradation to be digested in the small intestine. It has been reported [19] that steam flaking improved the NE value of corn by 33 % with the optimum flake density to be ranging between 0.32 to 0.39 Kg/L.

The results[20] of formaldehyde treatment of soybean and rapeseed meal showed that it increased the component of undegradable dietary protein (UDP) and especially useful for ruminants in certain physiological states[21].

Extrusion : Extrusion which involves steam treatment under high temperature and pressure for a short duration, of oil and legume seeds, makes the dietary proteins more resistant to microbial degradation in the rumen and increases the duodenal flow of amino acids. Various oil seeds such as soybean[22], rapeseed[23], Sunflower[24], cotton seed[25] and peas[26] were subjected to extrusion. Extrusion process has a favourable impact on milk production and composition[27] or meat production[28]. Beyond the increase in protein escaping the rumen, extrusion of feeds elevates the amount of carbohydrates which is susceptible to microbial attack in the rumen[26]. Extruded oil seeds are a good source of protected fat which partially avoids the unfavourable digestive interaction[20] and modifies the profile of fatty acids absorbed in the duodenum and thus the fatty acid composition of milk fat[29] or adipose tissue[30].

However a high fat content of oil seeds limits thermal and mechanical effects by reducing the shearing forces and heat elevation inside the extruder[31]. To overcome this, it is desirable to associate oil seeds with starch-rich grains such as cereals or legumes. Extrusion of pea-rapeseed blends resulted in increased delivery of amino acids to the intestines and also increased the proportion of $C_{18:1}$, $C_{18:2}$ and $C_{18:3}$ in the milk fat[32]. Recent studies[33] showed that 2 % ammonia level in conjunction with screw speed of 200 rpm reduced the glucosinolate content by 67 % in rapeseed meal during extrusion. The glucosinolates are normally hydrolysed to yield goitrogenic and other toxic substances and the extrusion process is expected to inactivate the enzyme myrosinase, which is responsible for the hydrolysis of glucosinolates.

Development of slow release urea products (SRUP) : The desirability of slow release of urea along with sustained release of starchy energy source could be achieved by extrusion of high urea and salseed meal. This product could be successfully utilised for replacing goundnut cake in the rations of cattle.

A mixture of finely ground grain (corn, sorghum, barley etc) and urea was expanded through a cooker extruder under moisture, temperature and pressure that cause starch to gelatinise[34]. The product was named 'Starea' and the same could significantly reduce the rumen ammonia concentration when fed to ruminant animals[35]. Starea was approximately equal to soybean meal as a protein supplement for lactating cows[34]. SRUPs like Salurea-50, Salurea-70, Salurea-90 and Tapurea-70 were developed and found to be alternative sources for replacing groundnut cake in the diets of ruminants[36, 37, 38].

Urea was treated with molasses in the ratio of 1 : 9 (w/w) at 110° C and the resulting product was named as 'uromol' [39]. Significantly lower urinary nitrogen excretion was observed in calves fed 'uromol' than those fed urea or formaldehyde treated groundnut cake rations[40]. Rice bran mixed with 'uromol' can safely replace of groundnut cake in ruminant diets[41].

Use of high moisture grains : With oxygen limiting storage structures, high moisture grains are stored without grinding which may be fed whole or rolled at feeding time. Use of bacterial preservatives to handle high moisture forages while ensiling is receiving attention. PROMAX,[42] a bacterial preservative was designed to stimulate production of lactic acid and propionic acid during fermentation with encouraging results.

Uniformity of the mix : Making a quality dry mixture with uniform dispersion of highly concentrated micro ingredients is a major challenge for the feed manufacturer. Animal performance will be adversely affected if feed ingredients, particularly micro ingredients such as vitamins, amino acids, trace elements and drugs are not properly incorporated. Segregation is the primary cause of reduced feed uniformity. In mixed feeds segregation is separation of one or more micro ingredients from the remainder of the mix[43].

PROTECTION OF DIETARY PROTEIN

In depth studies were carried out on the relative merits of different feeding systems with special reference to nutritional inadequacies faced by tropical grazing livestock[44]. It was postulated that wide scale differences in the response of animals to strategic suplementation in the form of concentrated feed could be attributed to variation in the quality of supplementation, grazing status and the physiological demand for which the supplementation was meant. A new school of thought was developed based on the protected protein concept in meeting the amino acids needs of genetically superior breeds of ruminants[45]. To achieve the objectives envisaged through this concept, attempts have been made in different countries either by protecting the natural protein sources through physical and chemical means or by choosing feedstuffs of varying nitrogen solubility/degradability to have varying degrees of rumen degradation.

Chemical treatments such as formaldehyde treatment and physical treatments such as heat treatment and extrusion cooking have increased the UDP contents of rapidly degradable protein supplements[46]. There was 20 % reduction of soluble N fraction of soybean meal due to heat and formaldehyde treatments compared to 11 % due to extrusion cooking. Formaldehyde treatment of groundnut cake reduced the effective protein degradability by 33 %[47]. Feeding of protein treated with formaldehyde, heat and tannic acid improved the trypsin enzyme activity compared to feeding of untreated protein.

PROTECTED FATS AS ENERGY CONCENTRATE TO RUMINANTS

Indian livestock breeds need a separate approach since the major limiting factor is energy deficiency in preference to protein supplementation. In this context it is quite appropriate to think of alternative means of energy supplementation to grazing livestock at times of sparse grazing status. Recently, attempts have been made to use cheaper oil sources as a concentrated form of energy in ruminants too as is in vogue in non-ruminant feeding. However, feeding of high fats in ruminant rations had the inherited disadvantage of depressing the fibre digestibility besides modification of unsaturated fatty acids to saturated acids through hydorgenation in the rumen. To safeguard the interests of the ruminants on high fat containing rations, fatty acids have been converted to calcium soaps for ruminal protection to serve as a concentrated source of energy. Calcium soaps of fatty acids have been proved to be effective source of energy besides supporting normal rumen fermentation with higher digestibility of fatty acids with the added advantage of easy mixing of modified oil form in comparison to natural oils[48]. Cacium salts of long chain fatty acids do not interfere with ruminal fermentation[49]. The adverse effects of energy deficiency during different phases of productive life cycle of sheep has been highlighted[50]. A technique of protecting vegetable oils such as coconut, palm and rice bran oils by reaction with calcium to form respective soaps has been developed[51] with more beneficial results obtained with rice bran oil.

PROCESSING OF NEW FEED RESOURCES

Indian south coastal region has been recently identified to be a potential belt for oil palm cultivation. In Andhra Pradesh state alone 0.4 m ha of land is likely to be covered with this new commercial oil crop shortly. Palm kernel cake (PKC) has been proved to be a viable substitute to replace groundnut cake up to 15 per cent level in complete rations of ruminants after oil extraction followed by grinding[52]. The processed new feed resource was also proved to be a strategic supplement on forage based rations[53] and is getting popularised with the feed industry. Encouraging results have been reported to include palm press fibre (PPF), another by-product of oil palm industry with urea-ammoniation enrichment (4 % urea, 40 % moisture with 20 d incubation) to replace paddy straw in buffalo rations[54, 55].

In a similar manner efforts should be made to identify new feed resources and to develop viable processing techniques to integrate the same under traditional feeding systems after thorough on-farm evaluation studies.

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NEW HORIZONS OF ANIMAL FEED INDUSTRY

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Compound Animal Feed Industry in India is in existence for the past 30/35 years only. The concept of manufacturing commercial balanced rations for livestock and poultry was introduced around 1960, and in 1967, the compound livestock feed manufacturers from all over India came together and formed an association which is popularly known as CLFMA.

The total strength of primary members engaged in feed manufacturing activity is around 110 (1979) and together they have an installed capacity to manufacture around 5 million tonnes of compound feed. Looking to the vast potential of feeds which could be fed to our livestock and poultry population, the current feed requirement is 7.5 million MT for poultry and around 36.3 million MT for cattle, totalling to 43.8 million MT. This could well rise to over 60 million MT by the year 2002.

This level of incorporation of compound feed in the ration of animals is lowest in India compared to other developing and developed countries. The compound feed used for livestock expressed with human population, is extremly low in India.

	1992		Feed per capita
	Feed Prodn. (million MT)	Population (million)	(million MT)
European Union	112.7	480	0.23
Central Europe	25.7	100	0.25
Asia/Pacific	109.5	2824	0.04
Latin America	32.6	437	0.07
Middle East/Africa	18.5	820	0.02
India	2.8	1000	0.003

Let us examine what are the various reasons for such low levels of feeding. We should examine this separately for cattle and poultry.

Cattle feed : The cattle feed requirement is high. Various estimates are available, based on level of feeding. Ideal requirement by 2002 would be 82 million MT and would be 53 million MT if 65% of animals are given compound feeds and the same would be 50 million MT if only milch animals are fed @ 50% of milk produced. Hence this shows that whatever be the level of feeding, the minimum feed required by 2002 would be in excess of 50 million MT.

In the current scenario, as of date, the cattlefeed industry is dominated by co-operative sectors who are aiming at integrated approach. Milk Cooperative are successful because;

- They barter milk for feed
- They provide veterinary services and artificial insemination facilities.
- They keep feed prices low and offer incentives to farmers once a year.
- They can afford to cross subsidise feeds from the receipts of milk.
- They offer credit on feed and also pay low for milk.

The other agencies involved in cattle feed manufacturing are from private, government, medium and small scale sectors. The share of compound feed from this sector is not very large, though increasing.

Many regional, local manufacturers are not the members of CLFMA, the reason being the eligibility criterion. The members of CLFMA are necessarily to have QC lab, should engage the services of qualified nutritionists and shoul adhere to minimum standards of quality. Many private secotr manufacturers who make feeds of quality which are not conforming to standards are not members of our association and their production, individually though not sizeable, together form a large proportion of total feed manufactured in the country. It is necessary that a minimum stipulated standard be fixed and be followed. CLFMA, through their scientific committee, has fixed standards and these are popularly known as CLFMA standards.

Keeping milch cattle in rural homes is more often a religious as well as psychological issue. Many farmers maintain very low productive cattle for the purpose of getting organic manure. Some animals are used for draft purposes and others are not fed enough to exploit the purpose of which they are kept. Feeding such animals on very low quality, low cost feeds does serve the psychological and emotional needs of farmers; but these result into wasteful use of the available resources.

It is not uncommon to find pelleted feeds sold even today at Rs. 1.5/kg. packed in new bags. These feeds are made of husks, low quality unfit materials and are made into pellets. Such feeds are likely to cause more damage to the animal rather than fulfilling its nutrient needs. There is a need to stop this practice through education of farmers.

Poultry feed : The situation in poultry sector is not as gloomy as in cattle feed. The layers and broilers are fed on compound feeds to meet their nutrient needs. Poultry keeping in India is no longer a hobby. It is now being treated as a business and hence the need to exploit the potential through better feeding. Such feeds whether made by compound feed manufacturers in their feed plants or made at the farm through home-mixing are designed to meet the major nutrient needs of birds. These are also fortified with minerals and vitamins and at many home mix plants, supplemented with synthetic amino-acids.

We find that as soon as the farm strength reaches above 30,000 birds, the farmer starts thinking of manufacturing feed by himself. The major reasons for switching over to home-mixing being :

- Farmer thinks that he is unnecessarily paying for the large overheads and profits of the feed manufacturers.
- The very concept that compound feed manufacture is a low technology involving few steps which he thinks are easy to follow.
- There are many chick suppliers and consultants who are ready to give some standard formulae to the farmer which are easy to adopt.
- Host of suppliers of raw materials are ready to supply ingredients to the home- mixers at competitive prices and on credit.
- There is an apparent saving in not using the new gunnies packing material.
- The cost of electricity and labour is considered free as this is either subsidised or the labour in farm is used to manufacture feeds.

Many such reasons put forth by the home- mixers are mostly misconceptions. However, some of these may carry some truth.

First of all, the feed manufacturing is no more a low-tech business. It requires careful balancing of as many as 30 to 40 nutrients. It is very important that the knowledge about the physiological and physical needs of the birds is known to the farmer as well as nutritionist. The particle size, the availability of each and every nutrient in every pick of the feed is very crucial for better performance. Uniform dispersion of all ingredients in the mixer and also their availability in smallest quantities in the feed is essential.

Compound feed manufacturers who analyse the feed ingredients in their QA laboratory are aware of the tremendous variations in the composition of ingredients which are supplied by various people and they are in a commanding position to correct the situation by varying the formulations.

Various antimetabolites present in different ingredients are known to nutritionists and they do take corrective actions either through analysis, using some substances which can bind, destroy or make the anti-metabolite not harmful to the bird.

The latest trends in applied nutrition, like use of probiotics such as the use of lactobacilli, yeast cultures or various other biotechnology products can be effectively used only by compound feed manufacturers.

NEW TRENDS

One of the latest trend which is becoming visible in India is the trend towards integration. Worldover one would notice that the integrated operations were initiated by the feed manufacturers. In order to increase feed business, they started buying back broilers and having taken the birds they entered the processing field. The marketing of fresh chilled broilers and frozen poultry products became their main occupation. Slowly they also integrated backwards into breeding and hatchery business. Such signs are also visible here in India.

Total integration was also started by the breeding and hatchery operators. This was started by Venkateshwara Hatcheries in India followed by Agritech Hatcheries. Arambagh Hatcheries, Singh Poultry, etc. to name a few. These trends offer definite scope and are likely to continue.

In the feed manufacturing business itself, we feel there is a tremendous scope for growth. Geographic expansions, presence in every potential pocket is possible and looking to the wide gap between the existing level of compound feeds manufactured and the trend projections of future offer various opportunties for growth, expansion and entry of new enterpreneurs.

The technological upgradation of feed manufacturing is still not done. We find that in the cattle feed segment, use of raw materials is still abundant. Some manufacturers make feed in mash form and some others, in both mash as well as pelleted forms. In poultry segment, mash is predominant. Pellets and crumbs have been manufactured by a few compounders with success. Still there is scope to develop feeds with processes of extrusion, wafers, etc. which would allow the use of low quality feedstuffs to be converted into value-added, better quality stuffs.

Concepts of full feeds are almost non-existent. We in India do not have the technology of converting the poor quality roughages into better nutrient products. We still do not have the machinery to convert these low bulk density materials into compact full feeds which can be easily transported and can be economically fed to livestock. There is a need to work in this direction.

Finally, I would like to conclude that the feed industry is an emerging industry. It has tremendous scope for growth. The need of the hour is to improve the manufacturing technology. There is also a need to improve the quality of the products we manufacture. The industry has to prove that compound feed manufacturing is a science, it is an art and it is this industry which is going to give the crucial input for improving the tremendous potential, the country possesses in the vast livestock and poultry population.

RESEARCH TECHNOLOGIES AND THEIR UTILITY IN ANIMAL FEED INDUSTRY

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The output of Animal Agriculture in 1996-97 was 827 billion which is 26 percent of the total value of agricultural sector and 7 percent of GDP. The Animal Feed Industry contributes 17 percent of Gross National Output. All major raw materials required for animal and poultry feed manufacturing are locally available. However, a recent estimate (Ranjhan, 1994) has shown the deficiency of concentrates at 47 percent.

STATUS OF ANIMAL FEED INDUSTRY

The world compound feed production in 1995 was approximately 550 million tonnes of which the Asia Pacific region amounted to 130 million tonnes (Rabobank Nederland, 1995). The world feed production for different species has been estimated as 32, 31, 17, 11, 3 and 6 percent for poultry, pig, dairy cattle, beef cattle, aquaculture and other animals, respectively. The USA and European Union manufacture about 115 million tonnes each. China produced 50 million tonnes in 1995. The share of India in global feed production is 7.3 million tonnes.

The compound feed production by the members of CLFMA was 2.72 million tonnes during 1995-96, representing 43% to poultry and 54% to cattle feed. The production from organized sector has always been small compared to the total production.

Factors influencing compound feed demand and hence raw material requirements are related to per capita meat consumption and production efficiency of livestock (Bourne, 1997). Production of traditional and non-traditional energy rich feeds and protein sources for livestock and poultry in 1994 in India was estimated at 10.5, maize ; 12.5, sorghum : 10.3, millets : 5.3, cassava ; 16.2, other roots and tubers; 3.3, soyabean meal and 23.3 million tonnes of rape, safflower, sesame and cotton seed meals (Reddy, 1996).

It is estimated that over 17.5 million tonnes of poultry feed and 18 million tonnes of compound feed for the projected 12 million population of crossbred cattle will be required by the turn of the century. Few non conventional feed resources (NCFR'S) have been used by the feed industry and it is necessary to augment their usage to bridge the gap of deficit.

TECHNOLOGIES ADAPTABLE BY THE FEED INDUSTRY

By pass protein for dairy animals :

The several systems in use for evaluating protein requirement and supply for ruminant diets are the UK Metabolisable Protein System (MPS), the French Protein Digested in the Intestine (PDI) System and the Cornell Net Carbohydrate and Protein System (CNCPS) of North America (Woodgate and Everington, 1997).

Feed crude protein (CP) entering the rumen is partially degraded by bacteria and protozoa to ammonia. The Rumen degradable protein (RDP) together with available energy is used for microbial protein synthesis. Microbial Crude Protein (MCP) and undegraded protein (UDP) then pass together into the small intestine for digestion and utilization. The *in situ* technique described by Φrskov and Mehrez (1977) is used to define the degradable fraction within the Metabolisable Protein and other systems. Protein degradability is determined *in situ* by incubating nylon bags containing measured amounts of feed in the rumen for a range of time periods upto 48 hours for concentrates.

Φrskov and Mc Donald (1979) derived an equation to relate effective degradability and rumen outflow rate per hour as,

Effective degradability (p) = $a + (b \times c)/c + r$

where

a = immediate or water soluble fraction
b = potentially degradable fraction
c = rate of degradation of the 'b' fraction
r = outflow rate per hour, respectively.

Further,

i)	Quickly degraded protein (QDP)	=	a(CP)
ii)	Slowly degraded protein (SDP)	=	{(bxc)/(c+r)} x CP
iii)	Effective rumen degradable Protein (ERDP)	=	0.8 QDP + SDP
iv)	Undegradable protein		(UDP) = CP - (QDP + SDP)
v)	Digestable undegraded Protein (DUP)	=	0.9 UDP - 6.25 ADIN

In general, rumen microbial protein alone should meet the needs of a cow yielding less than 20 Kg milk per day. Cows producing in excess of 20 Kg/day will require feed protein (DUP) in addition to microbial protein (Woodgate and Everington, 1997).

The first two limiting amino acids for milk protein secretion have been identified as lysine and methionine with histidine and leucine as potentially the third and the fourth limiting.

The rumen undegradable protein expressed as percent of crude protein must be 36% and soluble protein content should be maintained at 50% of RDP. Ruminal undegradability values of protein sources (Tables 1 and 2) can be used for formulating least cost concentrate mixtures for dairy cattle by the feed industry.

The protein sources with high RDP values may be subjected to processing treatments such as formaldehyde or heat to increase the undegradability. Protected proteins have a good potential in concentrate mixtures for high producing milch animals.

Table 1. Ruminal undegradability of protein supplements

Feed	Crude Protein %	Undegra-dability %	RDP g/Kg	UDP DM
Groundnut cake	43	0.26	318	112
Gingely cake	37	0.45	203	167
Soybean meal	48	0.46	260	220
Cottonseed cake	38	0.47	200	180
Copra cake	25	0.44	140	110
Sunflower cake	28	0.46	150	130
Safflower cake	23	0.29	163	67
Tobacco seed cake	32	0.38	198	122
Karanj cake	33	0.45	182	148
Niger seed cake	32	0.39	195	125
Rapeseed meal	37	0.21	292	78
Rubber seed meal	26	0.22	203	57
Silk Cotton seed cake	29	0.54	133	157
Corn gluten meal	50	0.55	225	275
Babul seed meal	15	0.46	81	69
Fish meal	45	0.41	265	185
Meat Meal	56	0.76	134	426
Dried poultry droppings	19	0.04	182	8
Feather meal (Hydrolysed)	82	0.65	287	533

FEED ENZYMES

Feed enzymes have been considered as necessary ingredient in today's diet formulations for monogastric animals. With the advent of glucanases for barley and pentonases (arabino xylanase) for wheat or rye, enzymes became standard ingredients in poultry feeds in early 1990s. A recent survey by Watt Feed Publications has revealed that enzyme usage was to the extent of 62% by European and 57% of the Asian Feed manufacturers. Poultry industry is the largest user of feed enzymes. Increased Non starch Polysaccharide (NSP) levels in poultry feeds leads to watery and sticky droppings. Wet excreta is a major problem in the laying hens where increased percentage of dirty eggs is associated with wet droppings. Xylanase is available for usage by the feed manufacturers to check wet litter condition in the feeds for layers and broiler parents.

A second generation of enzymes are now available to maximise protein and carbohydrate utilization. For example 'Allzyme Vegpro' marketed by 'Vetcare' improves the amino acid digestibility, increases the energy from soybean meal and results in savings in feed costs by 7% when supplemented to corn/soy diets in poultry. Broilers fed a corn/soy diet with a calculated analysis of 20.8% of protein and metabolizable energy of 2800 Kcal/Kg responded to a supplementation with 'Vegpro' with a 4% improvement in body weight and better feed effiencncy at 3 weeks of age. Pigs supplemented with 'Vegpro' during the growing and finishing phases improved feed conversion by 7% (Lyons, 1997).

Table 2. Ruminal undegradability of basal feeds

Feed	Crude Protein %	Undegra-dability %	RDP g/Kg	UDP DM
Maize	9	0.67	30	60
Jowar	10	0.25	75	25
Bajra	13	0.68	42	88
Barley	9	0.52	43	47
Rice bran	13	0.68	42	88
Rice bran extraction	14	0.52	67	73
Wheat bran	16	0.36	102	58
Mango seed kernel	9	0.68	29	61
Salseed meal	9	0.70	27	63
Tamarind seed waste	13	0.34	86	44
Cotton seed	17	0.54	78	92
Coffee seed cake	16	0.82	29	131
Coffee seed husk	11	0.57	47	63

The usage of byproducts such as rice bran, copra meal and rapeseed meal can be increased using exogenous enzymes. Allzyme lipase added at 100 mg/Kg to diets of broiler chickens (1 to 7 days) containing 200 g/Kg or 400 g/Kg of rice bran improved the growth rate by 11 and 15%, feed conversion by 9 and 15% and apparent metabolizable energy by 9 and 17%, respectively (Pluske *et al* 1997). Copra meal is a variable product containing 180 - 200 g/Kg CP, 80 - 120 g/Kg CF. It is low in lysine and methionine. Mannanase addition to broiler diets containing copra meal (200 g/Kg) gave improvement in performance. Rapeseed meal contains 35 - 38% crude protein and 12% crude fibre. The non starch polysaccharide fraction consists mainly of cellulase with smaller amounts of pentosans and lignin. Supplementation of cellulase and protease improved the value of rapeseed meal.

Phosphate pollution can be reduced by the use of a novel enzyme complex consisting of phytase and cellulase. With these enzyme activities combined, dicalcium phosphate in the poultry diets can be reduced by 0.1% . The removal of anti-nutritive effect of phytin also leads to an improvement in utilisation of amino acids and minerals.

The highly complex nature of the rumen environment presents considerable impediments to the application of simple enzyme systems. Fibrozyme, the first rumen protected enzyme is a multi enzyme cellulase complex obtained by the controlled fermentation of *Trichoderma viride*. Fibrozyme at 15 g/Cow/day improved feed intake and increased milk yield by 1.5 Kg.

About 35% of a 2 Kg broiler is a byproduct which must be processed. Offal subjected to enzymatic process gave higher nutrient density and proven cost benefits. One such product was claimed to improve broiler feed efficiency from 1.95 to 1.84.

RUMEN MODIFIERS

Traditionally, ionophores have been added to beef and dairy diets for the improvement in efficiency, weight gain or milk yield resulting from the shift toward propionate production by the rumen microflora. As the trend continues away from antibiotic additives in the rumen, the use of viable yeast culture in dairy diets has increasingly become standard in diets fed to high producing animals. Yea-Sac 1026 of Al:-tech is now known to stimulate certain microbial populations in the rumen and gastro intestinal tract thereby promoting digestion of fibre and removal of lactic acid from the fermentation, resulting into 5 to 8% increases in milk yield or weight gains.

ORGANIC MINERALS

Sodium selenite is presently being used as the primary source of selenium in animal feeds. Organic selenium is more bioavailable. Supplying selenium to broilers from selenium yeast reduced drip loss from broiler meat. Replacement of selenite by selenium yeast has given improvements of 2 - 4% in broiler breeder performance. Chromium has been recognized as an essential nutrient for animals. It is needed as a co-factor for insulin function. Organic chromium in the form of trivalent chromium yeast has shown positive responses of enhanced sow productivity, less carcass fat in pigs and poultry and improved immune status.

MYCOTOXIN BINDING AGENTS

The commonly encountered mycotoxins are aflatoxin, deoxynivalenol, zearalenone and fumonisins. The mycotoxin binding agents include synthetic anion exchange zeolite, bentonite, spent canola oil bleaching clays, activated charcoal, cholestyramine, hydrated sodium calcium alumino silicate (HSCAS) and yeast cell wall products. Feed companies and livestock producers are looking for feed additives that will reduce the adverse effects of mycotoxins in feed stuffs.

Yeast cell wall products, alumino silicates and bentonite may be better choices as feed additives when aflatoxin is the predominant toxin in the feed (Trenholm *et al*, 1996). A herbal product, Livol liquid, when added to drinking water of layer birds fed aflatoxin contaminated feed, increased egg production compared with that of control within five days. Protein utilization and fat absorption also improved in treated flocks (Choudhary, 1991)

The drive for a nutritional binder has led to the development of a much lower inclusion rate product compared to alumino silicate clays. Mycosorb (Mannan oligosaccharides), developed by esterifying yeast cell wall glucomannans, can specifically adsorb certain toxin molecules (Devegowda *et al* 1997). Aflatoxin is bound at highest rates, however, ochratoxin and the fusariotoxins prevelant in cooler climates are also adsorbed. About 0.05 Kg of the nutritional binder is as effective as 4 Kg of clay.

IDEAL PROTEIN

In order to rationalize amino acid requirements into a form that was easily applicable by the nutritionist and at the same time, overcome the problem of unwanted deficiencies of a single amino acid, Cole (1978) introduced the concept of an 'ideal protein'. It should be possible to establish an optimum balance of essential amino acids for growth which, when supplied with sufficient nitrogen for the synthesis of non-essential amino acids would constitute the 'ideal protein'.

Plasma protein has become a standard ingredient in pig starter diets. An alternative to plasma protein is to use enzyme hydrolysed cereal and yeast protein along with immuno globulins from egg. By using selected proteins all the essential amino acids can be provided in the diet. One such protein ingredient called 'Perfect Protein 1672' when added at 5% to a typical Pig starter feed provides the amino acid ratios required (Cole 1996). The optimum balance of essential amino acids in the ideal protein for pigs relative to lysine (= 100) are 50 - 55 for Methionine + Cystine, 18 for Tryptophan, 66 for threonine, 100 for leucine and 50 for isoleucine.

Lysine is used as the reference amino acid, although it is usually only second limiting after methionine in broiler diets. Amino acid ratios should be expressed in terms of digestible rather than total amino acids. The optimum ratio of Methionine + Cystine to lysine was between 75 and 78 to 100 and that of methionine to lysine was 41 - 45 to 100 for broilers.

A product 'Ultimate Protein 1562', which can satisfy the amino acid requirement in lactating ruminants, has been designed by taking into account the current knowledge of the metabolizable protein system (Woodgate and Everington, 1997). Evaluation of Ultimate Protein 1562 using *in situ* techniques and production trials have indicated that it is possible to balance the supply and requirement of amino acids in the dairy cow.

The production responses in terms of increased milk yield and milk protein yield would tend to support the view that balancing supply and requirement is beneficial.

'ZERO' SALMONELLA FEED

Conventional steam pelleting somewhat reduces salmonella contamination of feed. 'Expanding', pressure conditioning and high temperature short time (HTST) conditioning all describe a general technique of super conditioning which can kill salmonella more efficiently than pelleting alone.

Expanders are integrated into existing production lines as pressure conditioners between short term conditioning and the pellet press. Expander is used to pre gelatinise the starch and/or to breakdown the protein at elevated temperatures (90 to 160^0 C). It is a High temperature short time processor showing residence times of 7 to 17 seconds. Pressure is allowed to rise to 15 - 100 bars. For most products the length diameter ratio of the expander is equal to L/D = 7. Product densities range from 160 g/L to 760 g/L. Expanding feed at 90^0 C or higher followed by pelleting is an effective and relatively efficient way to produce a salmonella - free product.

Some feed manufacturers use the expander as the sole thermal processing equipment to produce finished products called expandate and expanded crumbles. When processing with the expander alone, a somewhat higher temperature may be required for reduction of salmonella than when expansion is combined with pelleting.

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PROCESSING, STORAGE AND HANDLING OF SOYBEANS AND SOYBEAN MEAL

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Soybeans represent the world's most important oilseed as a source of vegetable oil and protein. In India, soybean production increased dramatically, and in 1997-98 it is expected to be 4.9 MMT. The soybean seed contains 38% protein, 18% oil (0.5% lecithin), 15% soluble carbohydrates (*sucrose, stachyose, raffinose,* etc.), 15% insoluble carbohydrates (dietary fibre) and 14% moisture, ash & others. Soybeans also contain anti-nutritional factors e.g. trypsin inhibitors, allergens, saponins, lipoxygenase, phytoestrogens, phytin, lectins, oligosaccharides, haemagglutinins, etc.

PROCESSING OF SOYBEANS

The first solvent extraction plants for soybeans in the U. S. were erected between 1934 and 1937. Nutritionists found that the white meal was not optimal for use in livestock feeds because of presence of anti-nutritional factors. In 1939 Kruse and Soldner at Central Soya, Fort Wayne, IN, USA obtained the patent on a method for toasting meal under high-moisture conditions in vertically stacked kettles to produce a light golden brown product with improved nutritional value and handling properties. The term toasting usually implies treatment with heat under relatively dry conditions. In the case of soybean meal, the required procedure is more properly referred as cooking, because the best results are obtained under conditions of high moisture and controlled temperature.

The process for producing SBM for livestock feeding is logically divided into the following steps:

Receipt: The seed comes in bags (weighing approx. 90 kg) from the local mandi or may be from other states or countries. Out of a total lot, five bags are randomly selected for quality analysis of parameters like sand, damaged seed, foreign material, moisture, oil content.

Precleaning: This involves removal of trash materials, stones, excess sand/ silica, hulls, etc. by use of magnetic screening or rotary/ vibratory designs. It is advisable to store only cleaned seeds in silos.

Cracking: This involves utilization of two sets of corrugated rolls. The first set of rolls cracks the beans into halves and quarters and the second set cracks the beans into small size. Close monitoring is required for effective cracking. Dehulling can be done by passing cracked soybeans over vibratory screens with an aspiration arrangement to lift undesired hulls. The oil content of these hulls should not be more than 1.5 %.

Conditioning: The cracked beans are conditioned at 71-76°C at 9-10 % moisture level.

Flaking: This operation yields the flakes of a thickness between 0.25 to 0.30 mm. Extraction efficiency is directly proportional to flake thickness. Roll temperature reading and controlling may be one approach to automatically controlling flake thickness. The moisture content of the flakes should not be more than 7 %.

Expanding/extruding of flakes: The expander improves the extraction and reduces the energy requirements. The expansion process is followed by drying and cooling so that the final temperature and moisture of collets reaching the extractor are not more than 55-60° C and 7 %, respectively.

Extraction: The extractor is perforated moving mesh over which the prepared seed is brought in. The solvent required for the extraction is in ratio of 1:1 i.e. 1 kg of flakes will require 1 kg of solvent. Retention time is generally 30 minutes. The flakes that leave the extractor, containing approx. 39 % (21% for collets) solvent by weight are conveyed to a desolventiser toaster. The extraction brings down the oil content in meal product to 1-1.2 %.

Distillation: The final miscella containing around 30 % solvent goes to distillation section for separation of oil and solvent. In economizers, hot DT vapor is used to preheat the miscella and the flashed solvent vapors are collected and sent to condensers. Then the miscella is passed through two sets of preheaters and traces of solvent are removed in the stripping column by spraying miscella. The oil is cooled and sent for storage.

Hexane vapor collection system: Hexane vapor gets generated at various sections in the plant and these points are connected to condenser. The proper gradient of vacuum and cooling water temperatures should be maintained and monitored.

Desolventization and toasting: DT consumes about 50% of total energy required for processing and it destroys urease activity. The wet meal enters the top of DT and steam is fed in the bottom for complete counter currency of the steam to the meal.

Bagging of SBM.

HANDLING AND STORAGE OF SOYBEANS AND SBM

Soybeans and soybean meal are normally handled in bulk in developed countries, while bag handling is prevalent in developing countries. It is important to recognize the advantages and disadvantages of each system to minimize product deterioration and economic losses.

Whole Soybeans : Handling includes conveying and transporting from the farm to end-user. In the U.S., soybeans are handled as many as 15 times from the time they leave the farm until processing. This number may increase to as many as 20 for exported material. The structure of a soybean seed makes it susceptible to splitting and breakage during mechanical handling. The percentage of broken seed can be as high as 4.5%. The storability of soybeans is affected by the degree of damage to the seed coat and by other factors such as mold or insect attack. Therefore, it is necessary to inspect seeds for mechanical and other forms of damage prior to storage. It is better to separate the broken or split seeds by sieving if the percentage is high. Then this material should be processed first as opposed to long term storage with the original stock.

Soybean Meal : SBM is difficult to handle due to poor flowability and bridging characteristics. SBM tends to settle or consolidate over time. This phenomenon becomes more severe with increased moisture, time and particle size. Therefore, it is advised to store bulk SBM in flat storage buildings than in vertical silos. Addition of of calcium carbonate, calcium bentonite, or sodium bentonite at a level between 0.25 to 0.5% is effective in improving the flowability of SBM.

FACTORS AFFECTING SAFE PRODUCT STORAGE

The three major factors are moisture content, temperature and duration of storage. The general condition of the product and amount of foreign materials also affect their storability.

Moisture Content : Soybeans contain moisture in the range of 12 to 15% (wet basis) at harvest time. Soybeans with the moisture level above 13% should be dried to reduce the risk of deterioration due to seed respiration, mold attack, spontaneous heating and reduced germination. Moisture is present in two forms in grains and oilseeds:

* Free moisture in the vapor form and is removed during drying.
* Bound moisture remains locked in the molecular structure of the grain and cannot be removed by drying.

Soybeans and SBM are hygroscopic materials and will either lose (desorb) or gain (adsorb) moisture from the surrounding air. The moisture level reached by a product at a given constant temperature and equilibrium relative humidity (ERH) is its equilibrium moisture content (EMC). The EMC of soybeans and SBM by desorption are higher than that by adsorption under the same set of conditions. This phenomenon is known as hysteresis. It occurs in most agricultural products such as cereal grains, oilseeds, leathers, meats and even vegetables. In soybeans and SBM hysteresis is less pronounced compared with that of cereal grains. Furthermore ERH of the meal is lower than that of whole soybeans at all moisture levels because of its lower oil content. This means that under the same air relative humidity, SBM will have higher EMC than whole soybeans.

The rate of moisture adsorption or desorption is directly related to the manner by which a product is exposed to the atmosphere. Soybeans kept in jute bags tend to gain or lose moisture more readily than soybeans in bulk form. So, bag storage has as self-ventilating and cooling characteristics that makes it the preferred method over bulk system in many developing countries.

Temperature : With the increase in temperature growth of fungi and chemical changes such as oxidation increased in both whole soybeans and SBM. Range between 27 and 35°C is ideal for the growth and reproduction of insects, but they die of starvation when temperature goes below 16°C. Exposure to temperature above 60°C kills most insects in 10 minutes.

Soybeans with a moisture contents of 14-14.3% and maintained at 5-8°C can be stored for over two years without mold damage while soybeans kept at 30°C can be invaded by molds in a few weeks and severely damaged in six months. Temperature also influences moisture migration. Because of the insulating properties of grains, the effect of diurnal temperature changes on the stored grain is minimal but is cumulative.

Duration of Storage : Deterioration of soybeans and SBM in storage is a combined function of its moisture content, temperature and duration of storage. Therefore for safe storage, a combination of these three factors providing unfavorable conditions for mold development, such as low product moisture, low temperature and short storage period are desirable.

FOREIGN MATERIALS PRESENT

Foreign materials in soybeans are defined in U.S. Standards as all materials that pass through a 3.2 mm round-hole sieve and all materials other than soybeans remaining on the sieve. Fine particles tend to segregate during bin loading and occupy void spaces in the central region of the grain mass. Meanwhile the large and lighter materials will accumulate close to the walls of the silo. Cleaning soybeans prior to storage will minimize the risk of spoilage and economic loss.

PRODUCT CONDITION AND HISTORY

Sound soybean kernels will store better than kernels damaged by freezing, cracking, splitting and storage fungi. It is generally recognized that a sound seed coat provides some degree of protection against insect and fungal attack. In terms of insect attack SBM is more susceptible to moth and red flour beetle infestation than whole soybeans.

DETERIORATION INDICATORS

Heating: High grain temperatures normally indicate either microbial or insect activity. If left unchecked, this may lead to heat-damaged or charred grains due to the phenomenon of stack burning. In soybeans also it is initiated by microbial or insect activity. However as heating progresses above 50°C, the oxidation of oil in soybeans becomes self-sustaining process. At the extreme temperatures like 150°C, charring will definitely occur and spontaneous combustion or fire may become a distinct possibility, if sufficient oxygen is present at the hot spot.

Change in color and appearance: In general, sound soybeans are plump with bright uniform tan and not green color and free from unusual spots and shriveled appearance. Discolored soybeans indicates inferior quality and lower market value. The change in color is due to mold invasion accompanied by microbial respiration and subsequent heating. This deterioration process can be detected by periodic drawing of samples from the soybean stored as part of an integrated approach to quality maintenance. Soybeans may be transferred to another silo thus breaking any hot spots present and cooling the soybeans during conveying process. But this is costly and may increase the percentage of broken or split soybeans.

Mustiness and off-odour condition: Mustiness indicates an advanced stage of insect or mold infestation and should be corrected immediately. Aeration should be done to remove bad odour and cooling should be done. These beans should be given first preference for the use. Fumigation should be done if insects are present. Rancidity of oil component may give bad odour also.

Presence of storage insects

Lumping and caking: It indicates a very advanced stage of fungi invasion in soybeans and SBM. In a bag system of storage,caking of soybeans and SBM may occur due to increased moisture content adsorbed from the atmosphere, leaky roof, or due to capillary moisture from the floor. Capillary moisture may be avoided by putting the bags on pallets. Concrete floors can be made water-proof during construction by installing plastic sheets as moisture barriers before pouring in the floor slab.

CHEMICAL CHANGES DURING STORAGE

Stored soybeans may undergo physical, physiological or chemical changes even under ideal conditions. One common indicator of chemical change is the level of free fatty acid (FFA) present. An increase of FFA above 1% may translate into lower quality of its oil content. Other important changes include decline in soybean seed viability, change in the grain color, increase or decrease in moisture content, decomposition of phospholipid, and the denaturation of protein. Whole soybeans are more resistant to deterioration during storage than SBM. Full fat SBM deteriorates more rapidly than defatted SBM because of higher oil content.

MAINTENANCE OF QUALITY

Once the soybeans reach maturity and are harvested their inherent quality is fixed and can only be maintained by proper drying, cleaning and conditioning. The measures taken are as follows:

Temperature monitoring : In small farm storage silos, temperature probes can be used whereas, in large commercial silos, thermocouple wires and multipoint potentiometer are used.

Product sampling, inspection and testing : Systematic monitoring can be done by regularly taking samples of stored soybeans and SBM and analyzing in the laboratory for signs of deterioration. During sampling operation, one also should inspect the storage facilities for signs moisture accumulation or roof leaks and other physical damages to the storage facilities.

Cooling by aeration : The primary aim of aeration is to make the temperature of the grain bulk uniform. It may also be used to hold partially dried soybeans for a few days to prevent spoilage before proper drying. Aerating soybeans in silos can be done by pushing the air (positive pressure) or pulling it (negative pressure) through the grain mass.

SUMMARY

The success in storage and handling of soybeans and SBM is dependent upon the understanding of the combined effects of three most important factors i.e.temperature, moisture and time.It should be remembered that the original quality of the soybeans and SBM cannot be improved upon and that the quality will decline with time.However deteriorationcan be reduced to an acceptable level by keeping the product cool and dry during the storage period. This will assure the availability of a good quality product when needed for processing and marketing. extraction and production of good quality SBM.

KEY STEPS IN THE PROPER NUTRITION OF DOGS

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There are a number of important considerations in the proper nutrition of dogs. In this presentation the author will focus on applied nutrition and will consider nutrient responses and feeding regimens which one would likely encounter. The presentation will be organized about the following key areas which will include: palatability, protein and amino acids, energy and minerals. A brief overview on feeding dogs during the reproduction, growth, adult and geriatric stages will be covered.

PALATABILITY

Palatability is an important issue in canine nutrition. If a product lacks palatability the dog may refuse it and not obtain satisfactory nutrition. Three important factors influence palatability of a dog food. These factors include flavor, aroma and physical characteristics. Surprisingly, the flavor of a dog food has only a mild effect on palatability and will seldom give more than a mild boost to palatability. Aroma of the food, at most, is an attractant and will draw the dog to the food but will have little or no effect on the dogs preference for that food. Physical characteristics, however, have a major effect on palatability of the food. Factors such as wetness (moisture content), crunchiness, chewyness, plasticity and mouth feel have major influences on palatability. Inclusion of water or high moisture ingredients has a major positive effect on palatability. Moisture content is one of the major reasons that meat tissue is highly palatable to dogs. Adding 50% moisture by weight to a dry dog food will markedly enhance the taste.

PROTEIN AND AMINO ACIDS

Dietary proteins are necessary to provide those essential amino acids that are not manufactured in sufficient quantity by the dogs. A protein can only perform to the extent of the most limiting amino acid in the diet. Therefore, if lysine is marginally deficient and all nine of the other required essential amino acids are adequately present, then performance will be limited to the extent of the deficiency of lysine. The ten essential amino acids required by the canine include:

arginine	methionine
lysine	phenylalanine
isoleucine	threonine
leucine	tryptophan
histidine	valine

Generally, Lysine is first limiting in canine diets. This deficiency can be alleviated by adding synthetic lysine or else by adding an ingredient such as soybean meal which contains high lysine. Methionine, threonine or isoleucine can be limiting depending on the protein source. There are a number of protein sources which provide varying balances of amino acids. Soybean meal, corn gluten meal, meat and bone meal and poultry byproduct meal are very good amino acid sources for dogs when blended correctly with other ingredients.

Protein (or amino acid) deficiency signs are unfortunately non specific. Deficiency signs include weight loss, lowered food intake, muscular wasting, emaciation and death. Protein (amino acid) deficiency should be considered whenever there is severe weight loss in dogs. More will be covered in this area when feeding for growth is discussed.

Protein, fat and carbohydrate provide a source of calories for the dog. Dietary fat is a concentrated source of calories. There is no known fat requirement as such, however, linoleic acid, a component of fats, is required primarily to maintain normal hair and skin condition. A marginal deficiency of linoleic acid will slow the rate of hair growth whereas severe deficiency results in skin lesions. Many vegetable oil sources such as safflower oil, soybean oil and corn oil are excellent sources of linoleic acid. Natural oil from inclusion of corn in the diet is sufficient to meet the linoleic acid needs of the canine.

Carbohydrate is not required by dogs. Nevertheless, dry type canine diets frequently contain from 40 to 60 % carbohydrate. For that reason carbohydrate is an important contributor of calories in dog foods. Carbohydrates must be cooked prior to feeding. Insufficient cooking of carbohydrate results in insufficient digestion of carbohydrate and will cause digestive impairment.

DIETARY ENERGY

Protein, fat and carbohydrate are necessary substrates for production of calories in the body for metabolic reactions and to provide body heat. Metabolizable energy (ME) which is total energy minus that energy lost in feces and urine will be cited frequently in the presentation. A reasonable estimate for ME contribution by nutrient category is as follows:

Nutrient	ME Contribution
Protein	3.50 Kcal/g food
Fat	8.46 Kcal/g food
Carbohydrate	3.50 Kcal/g food

A number of factors influence the caloric requirements of dogs. These factors plus the relative energy needs are cited below in percent:

Maintenance (resting)	100%
Gestation (trimester 1 & 2)	100%
Gestation (trimester 3)	125%
Lactation	200-300%
Moderate work	120%

The adult dog daily caloric requirement varies also according to the size of the dog:

Body Weight (Kg)	Kcal ME/Kg BW/da
5-10	85
10-35	60
over 35	50

CALCIUM, PHOSPHORUS AND VITAMIN D

Calcium, phosphorus and Vitamin D have key roles in bone formation in dogs. Calcium and phosphorus are key structural components of the bone. Vitamin D is predominantly involved with absorption of calcium.

Calcium is the predominant nutrient in this set since it is directly involved in some of the more serious bone disorders. Clinical signs of calcium deficiency and toxicosis have been observed. Some foods are almost devoid of calcium (e.g. meats) and when fed result in severe rickets. Symptoms of calcium rickets include arrested growth, immobility and elevated serum alkaline phosphatase. These deficiency signs can be corrected within a two-week period by feeding a calcium adequate diet.

The level of dietary calcium should always exceed the phosphorus level in the diet. The preferred ratio of calcium to phosphorus by weight is within the range of 1.2:1 to 2.0:1. If calcium and phosphorus levels are adequate and if phosphorus level exceeds calcium growth will be impaired in puppies. In adult dogs this type of impaired balance over a long period of time will result in loss of bone and eventual immobility (nutritional secondary hyperparathyroidism).

Phosphorus or Vitamin D deficiency in dogs is almost never a problem. Plant and animal sources are generally adequate in phosphorus level and availability. The Vitamin D requirement of the canine is extremely low. Work at Ralston Purina has indicated that omission of Vitamin D in a canine diet did not show evidence of deficiency over a two-year period.

Most nutritional bone problems are associated with calcium. There are several rules for proper calcium nutrition:

1. Calcium level in the diet should not be below that of phosphorus.
2. Dietary calcium level should not be below 0.6% (DMB) as marginal deficiency starts to occur at that level.
3. Calcium level should not exceed 1.8% (DMB) since excessive calcium will cause bone structural defects.
4. Dietary calcium levels of 4.0% (DMB) will arrest growth.

Bone meals, dicalcium phosphate and defluorinated phosphate are good sources of calcium and phosphorus. Calcium carbonate is a good source of calcium.

REPRODUCTION

The time prior to breeding the dam is a time when the dog should be in good condition, carrying sufficient body weight reserve. Food intake should not be limited at this time except in cases of obesity. Obese dogs need to be placed on a weight reduction program using a good quality diet prior to breeding. Intake of B vitamins plus Vitamin A is important at this stage since many of these vitamins have been implicated in birth defects. After breeding, if the female is not overweight she can be fed ad libitum. If a controlled feeding regimen is used then the owner must gradually increase food by 25% during the third trimester of pregnancy. During lactation dogs should almost always be fed ad libitum since that is the time when total food intake must increase by 2 - 3X in order to produce sufficient milk for puppies. Most puppies start to eat solid food by 4 weeks and can be weaned by 6 weeks.

General recommendation - 21% protein, 3,500 Kcal ME/Kg. diet (DMB)

GROWTH

Growing puppies should be fed a diet that meets the standards presented prior in this presentation. At six weeks of age a puppy requires 3X the caloric (food) intake compared to the adult requirement. This requirement declines gradually to 2X by 20 weeks of age and then gradually declines to the adult requirement by one year of age.

It is very important not to overfeed pups during the first year. Work at Ralston Purina Co. has indicated that when pups are limit fed (25% less than ad libitum) they will have markedly less hip dysplasia by 2 years of age and markedly less osteoarthritis in the coxofemoral joint by 5 years of age.

General recommendation	27% protein, 3,500 Kcal ME/Kg diet (DMB) Limited food intake recommended

ADULT

Adult dogs (1 - 7 yr.) have the lowest requirements than at any stage in life. Of course, any stress such as reproduction or hard work will elevate that requirement. In hard working dogs the caloric intake must be initiated at onset of the work conditioning period. This allows the dog to build up fat reserves which are utilized during periods of hard work. Dietary supplements are almost always counter productive during this stage.

General recommendation (adult) - 16% protein, 3,000 Kcal ME/Kg diet (DMB)

General recommendation (work) - 27% protein, 4,400 Kcal ME/Kg diet (DMB)

GERIATRIC

Nutrition during the geriatric stage (8 yr. plus) has been receiving a good deal of attention recently. Lowered ME intake is recommended at this stage to prevent excess fat deposition. Recent data is indicating a need for elevated protein over that of adult dogs during the geriatric stage.

General recommendation - 25% protein - 3,000 Kcal ME/Kg diet (DMB)

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RECENT ADVANCES AND FUTURE STRATEGIES IN NUTRITION FOR FRESHWATER AQUACULTURE

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Aquaculture, which was largely a subsistence level activity only a few decades ago, has become a reasonably major economic activity in most parts of the country. This improvement of aquaculture from traditional extensive systems to semi-intensive and intensive levels basically by increasing fish stocking density to maximise utilization of water resources is directly related to advances in the concept of nutrition and feeding practices which have taken place during recent years. As the stocking density of fish exceeds the natural carrying capacity, the dependence shifts from natural food to supplementary feed, often necessitating a nutritionally balanced compounded feed to sustain the targeted fish production. Although carps (Indian major carps and exotic carps) still form the mainstay of freshwater aquaculture in India, contributing over 1.285 million tonnes of the total aquaculture production of 1.439 million tonnes during 1993[1], the scenario is fast changing with the addition of catfishes *(Clarias batrachus, Heterpneustes fossilis, Ompok pabda, Aorichthys aor and Pangasius pangasius* etc.) and freshwater prawns *(Macrobrachium rosenbergii* and *Macrobrachium malcolmsonii)* to cater to the increasing domestic needs and to a limited extent for export to the neighbouring countries.

In aquaculture, adequate nutritional practices play pivotal role not only to increase the yield significantly but also on the product quality, improvement in the reproductive performance, development of immunity towards infection etc. Depending on the intensity of culture operation the cost of feed has been reported to be 57-87% and constitute the single largest input cost[2]. It is, therefore not surprising that knowledge on the aspects of nutrition of various finfish and shellfish form the frontier areas of research in aquaculture.

RECENT STUDIES ON NUTRITIONAL REQUIREMENT OF FRESHWATER FISHES

Since feed is the principal operating cost in the production of fish in captivity, precise information on nutritional requirement is essential in order to formulate nutritionally balanced feeds tailored to the needs of the various maturity stages of the fish. This information should also make it possible for the feed to be cost effective. Fish as a group is fundamenally different from other vertebrate animals in that they require more (35-55%) dietary protein to reach the maximum growth rate[3-6]. In common with other major components as energy source optimal dietary protein levels for fish are dictated by dietary protein to energy ratio plus the protein quality (amino acid balance and digestibility) and dietary non-protein energy sources. Excessive non-protein energy intake resulting from high digestible energy to dietary protein ratios often causes cessation of feeding before sufficient protein is consumed since ingestion rate is primarily determined by total available dietary energy content[7].

Protein and amino acids : Several investigations have been conducted to determine protein requirements for specific fish species. Optimum protein requirements for Indian major carps range between 30-45%[8-9]. Studies on protein : energy in the carp *Labeo rohita* indicated that a feed with 38% protein and 400kcal/100g energy (having protein:energy of 95 mg protein/kcal) should be enough for optimal growth[10]. A minimum of 355 kcal/100g is, however, essential for efficient nutrient utilisation and growth in a 40% crude protein diet with 29.5% metabolisable energy as carbohydrate [11] in *Cirrhinus mrigala*. Seenappa and Devaraj [12] found that the carp *Catla catla* grows very well with 30-35% protein diet containing 4% level of lipid and 35% carbohydrate.

Fishes are ammonotelic and ammonia, the end product of protein metabolism is excreted mainly through gills into the ambient water. Ammonia requires less energy for excretion than urea or uric acid and as a result energetic value of protein for fish is higher (=4.6 kcal/g) than for ureotelic mammals and uricotelic birds (=4.1 kcal/g). Thus, in many dietary protein requirement studies fishes were probably offered higher metabolisable energy in high protein diet than low protein diets. Therefore, protein-energy studies examining several energy concentrations within each of several dietary protein concentrations could provide better estimates of quantitative dietary protein requirement of fishes[13-14].

Dietary protein requirement generally decreases with increasing age/fish size and like most other animals, young ones need more protein than older individuals. For example, during spawn to fry rearing of Indian major carps, dietary protein levels should be reduced from 40% to 35% during fingerling stage with further reduction to 30% for juveniles. With increase in water temperature, growth rate increases without raising dietary protein level because of increased specific protease activity in the intestine leading to improved protein efficiency coupled with higher intake per meal. Dietary protein level may be lowered without affecting growth performance by dietary manipulation of the pertinent energy source as protein sparing effect of lipid is well known.

Essential amino acid requirements are the most basic data for formulation of excellent quality feed with cost effective nutrient sources as well as on the possibility of utilizing less conventional plant and animal protein sources which may be deficient in certain amino acids. The nutritive value of dietary protein is governed by extent to which its content of essential amino acids stimulate the needs of the species in question.precise data on amino acid requirement will be critical because of possible ontogenic changes in the requirements[15].

Estimation of total free amino acid composition of fertilized eggs and profile of amino acids of muscle tissue used to be a fairly good guideline for dietary essential amino acid profile of fry and fingerlings of a given fish species in the absence of detailed information on amino acid requirement. But quantitaive amino acid requirements of several fish species have recently been reportedly based on weight gain, feed efficiency, plasma free amino acid level of fish fed graded concentrations of a particular amino acid (while levels of other amino acids remained fairly constant). Biochemical estimation methods are also available (Fig. 1) [16] Ogino[17] assessed optimal pattern of indispensible amino acids retained in the carcass of the fish fed a high quality protein diet.

Fig. 1 BIOCHEMICAL METHODS TO ESTIMATE AMINO ACID REQUIREMENT IN FISH

i) Intraperitoneal 14_c(u)-glucose injection to fish

→ Fish sacrificed, liver tissue protein separated, hydrolysed and constituent amino acids resolved over 6d-period

→ Amino acids monitored by paper chromatography or TLC

→ Those amino acids which contained radioactiveity were obviously synthesised (Non-essential amino acids) by fish through intermediary **metabolism**

→ Conversely those amino acids which did not contain radioactivity could not **be synthesised by fish.** These were classified as essential amino acids

→ Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenyalanine, Threonine, Tryptophan and Valine.

ii) Other biochemical method includes studies on oxidation of an intraperitoneally injected pulse of the ^{14}C-labelled target amino acid at different levels of intake. At low dietary levels of amino acids little of it is oxidised. Once requirement level is reached oxidation of amino acid increases rapidly.

The range of amino acid requirements (% protein) of Indian major carps are as follows : Lysine 5.7-7.0; Methionine 1.5-3.5; Arginine 4.8-5.8; Tryptophan 0.8-0.9; Threonine 3.9-4.2; Valine 3.6-4.5; Leucine 3.7-6.9; Isoleucine 2.3-3.8; Histidine 2.1-3.0; Phenylalanine 3.7-8.0 [18-20]. The requirement of essential amino acids (except tryptophan) for catfish *Clarias batrachus* is also now known [21].

Lack of precision over measurement of amino acid requirement stems from a number of reasons. Growth rate of several fish species given a diet in which the protein component is composed of free amino acids is very often inferior to that of fish given a diet of nearly identical composition but composed of protein[22]. Secondly with subtances that are readily soluble in water, there is an obvious dangergers that losses will occur as a consequence of leaching.

Lipids and fatty acids : Next to protein, lipids form the major dietary components of fish. Besides being the most energy rich of all classes of nutrients, lipids are the sources of various fatty acids some which are essential for maintenance and integrity of cell membranes. To some extent essential fatty acid (poly unsaturated fatty acids (PUFA) linoleic 18:2 n-6 and linolenic acids 18:3 n-3) requirements of fish are related to their feeding[23]. The lipids of component members of aquatic ecosystems were shown to differ markedly with those of their terrestrial components. In particular lipid from fish are rich in mono and poly unsaturated fatty acids. The degree of unsaturation greatly influences the physical properties of the constituent lipids. PUFA containing 5 or more double bonds are referred to as highly unsaturated fatty acids (HUFA) and this distinction is important since the recent researchers indicated that HUFA provides certain health benefits which are not obtained from PUFA. The important HUFA are eicosapentaenoic acid (EPA) 20:5 n-3 and docosahexaenoic acid 22:6 n-3. Lack of essential fatty acids eg. linolenic acid, 18:3 n-3 results in poor growth, feed efficiency, impaired reproductive performance in several fish species. Dietary linolenic acid may be chain elongated and further desaturated to 20:5 n-3 and 22:6 n-3 which get incorporated into the membrane lipids in some fish species *Clarias batrachus and Heteropneustes fossilis*[24]. Again some fish species like Tilapia requires 18:2 n-6 or 20:4 n-6 for optimum growth and development as opposed to fatty acids of n-3 series. One of the reasons for this variability is the endogenous difference in the relative capacity of different fish species to elongate/desaturate the 18 carbon fatty acids.

Information on lipid requirement for warm water fishes are still inadequete. Indian major carp species have the ability to digest lipids as evident from fairly high specific activity of intestinal lipase[25]. Generally 7-8% lipid is provided in the carp diet and they appear to have a requirement of both n-3 series and n-6 series fatty acids. Phospholipids represent the second largest lipid component after triglycerides. In conjunction with proteins, phospholipid form the basic lipo-protein structure of biological membrane and act as emulsifying agents. Recent researches[26,29], indicated that phosphiolipids are dietary essentials for carp larvae and that they respond highly favourably to phospholipid supplemented exogenous feeds through significant increase in survivality and growth. Generally larvae/ spawn of fish and prawn are reared in the laboratory for the first few days on live food organisms. These of course supply all the essential nutrients but some organisms like *Brachionus plicatilis* and *Artemia salina* do not always provide an adequete complement of essential fatty acids. Methods of modifying the fatty acid profile of these organisms so that they do supply a sufficient PUFA to the fish and prawn larvae have been developed by Watanebe[28] by feeding the rotifers on baker's yeast *(Saccharomyces cerevisiae)* which had been grown in a medium supplemented with fish oil (rich in PUFA or n-3 series) and also by directly feeding the rotifers on emulsion of lipid (on appropriate fatty acid composition), raw egg yolk and water together with baker's yeast. It seems probable live food organisms are to be used for the early larval rearing stage of freshwater prawns in particular until a satisfactory alternative is found and then the methods of Watanabe[28] will be highly relevant. The essential fatty acid requirement of some of the carp and catfish are shown in the following table.

Fish species	Requirement of fatty acids	References
Cyprinus carpio	1% 18:2(n-6) & 1% 18:3(n-3)	Watanbe *et al.*[29]
Ctenopharygodon iddela	1% 18:2(n-6)	Takeuchi *et al.*[30]
Catla catla	18:2(n-6) & 18:3(n-3)	Mukhopadyay and Rout[25]
Heteropneustes fossilis	18:2(n-6) & 18:3(n-3)	Bandyopadhyay *et al.*[24]
Clarias batrachus	18:2(n-6) & 18:3(n-3)	Mukhopadhyay and Mishra[23]

Vitamins : With the intensification of aquaculture systems, the nutritional importance of vitamins has grown steadily in recent years[11]. Water soluble and 4 fat soluble viatmins have been found to be essential for optimal growth of fish in general under intensive rearing. The quantitative requirement of vitamin C has been determined in carp and catfish recently by feeding purified diets deficient in vitamin under study and comparing various growth parameters,tissue biochemistry and nutritional pathology in terms of tissue architectural changes in fish fed nutritionally complete diets[31,32]. Quantitative vitamin requirements were then determined by feeding graded levels of the vitamin under study withpurified diets. The dietary level that resulted in normal weight gain and absence of deficiency signs was considered to be the minimum dietary requirement for that specific vitamin. Measurement of activities of tissue enzymes of which the vitamin (mainly B group vitamins)is a component coenzyme have been used as an adjunct to growth measurements.

All the three Indian major carp species and the catfish *(Clarias batrachus)* lack l-gulono -lactone oxidase, the terminal enzyme for the conversion of glucose to ascorbic acid through glucuronic acid pathway and exogenous supply alongwith feed is mandatary. Vitamin-C (ascorbic acid) is involved in biochemical reactions in practically all groups of nutrients. All the vitamins required for optimal growth and health can be found in the dietary raw material before they are processed. The processing and subsequent storage of raw materials results in their being vary variable levels left when the time comes to combine them into fish feeds. It is, therefore, usual to assume that the raw materials contain no vitamins and addition of vitamin premix is therefore mandatory. Again the addition of adequate vitamin level into the feed at the time of manufacture may not guarantee that at that particular level it will reach the fish. Some vitamins (particularly vitaminC) are labile and lose their potency if they are stored under warm and humid conditions. this is the reason that if the optimum level is 200mg/Kg it would be necessary to add at least 400mg/Kg to the dry feed at the time of manufacture.

NUTRITIONAL INFORMATION AND FISH FEED DEVELOPMENT

In order to maintain the fish and support the maximum growth, efficient and scientifically founded feeding are essential. growing fish needs nutritionally complete feed for the entire culture operation especially in intensive culture system. Feeding level and composition of complete feed are determined by the nutritionalrequirements of the fish species and some understanding of the feeding behaviour. The only way to feed fish diets composed of a mixture of different ingredients which will have the proper ratio of energy and protein, vitamins and minerals is to compound these ingredients in the form of pellets. Two aspects of pelleted feeds are important.

i) their nutritional value and
ii) the technology of their production.

The quality maintenance of ingredients (including the destruction of anti-nutritional factors (particularly in plant protein sources used) is very much important which decides the conversion efficiency of the feed. In the pursuit of sustained production of componded feeds to meet the growing demand of aquaculture, there is a constant search for feed ingredients. the main factors determining which sources of ingredients are best to use in a particular location include fish species to be farmed, the geographic availability of the potential feed component, quatities available (including seasonal fluctuation), competition for use in domestic animal feeds, price, transport, storage etc.

Since fish requires relatively higher protein feeds and since the protein component in the feed is the most expensive, a rational approach for identifying and selecting protein sources is essential to make the cost of the feed economical. In this context data on nutritive evaluation of ingredients including nutrient digestibility are generally obtained first. Computersied linear programming system allow data on nutritional requirement of fish, nutrient composition, price of each ingredient alongwith constraints on their inclusion if any (e.g. minimum or maximum level of inclusion) is then used for least cost feed formulation.

In the last decade, there has been considerable research efforts on development of practical fish feeds using a wide array of ingredients, digestibility evaluations, determination of proximate composition, amino acid, fatty acid profile etc. Efforts to compile and systhesise these information to make better use of the knowledge have been initiated recently. In this context a pelleted feed for carp under the brand name "CIFACA" has been developed and released in the market. This feed which was formulated mainly from agricultural and food industry by products and prepared using improved feed technology was evaluated through repeated pilot scale trials followed by farm testing in Institute's farm ponds at Kausalyaganga, Bhubaneswar for intensive carp culture.

The annual feed requirement depends on area under culture, potential FCR (feed conversion ratio) of the feed and intensity of culture system. At least 700,000 ha water area is now under freshwater aquaculture. If we consider an approximate demand of 2 tonnes/ha on the average then there should be an immediate need of 1.4 million tonns/year with a potential value of about 1000 crore. Several feed mills have been set up in India adopting indigenous technology. This has opened up new possibilities for feed manufacture as an ancillary aquaculture industry and more research -industry interaction on specific problems relating to feed development, testing and feed management in near future.

FUTURE THRUST AREA IN AQUACULTURE NUTRITION RESEARCH IN INDIA

Although researches in fish nutrition have provided a great deal of information on the nutritional requirements of fin fish and shell fish, different ingredients used for feed formulation, use of feed additives including attractants, non-hormonal and herbal growth promoters etc., much work willl still have to be done for sustained aquaculture production. Some of the probable thrust areas are briefly stated.

i) It is well recognised that quality of aquaculture feed primarily depends on protein source since it accounts for about two third of the feed cost. Fish meal still remains the preferred choice for dietary feed input due to its premium match of essential amino acids and fatty acids in relation to requirements of fish. It is desirable to strengthen research on a number of processed invertebrate meals (like spray dried blood meal, rendered meat cum bone meal, hydrolysed poultry feather meal) single cell protein (SCP) including algal SCP (Spirulina sp.) fungal SCP (Saccharomyces sp.), oil seed meals (like defatted soyabean meal) etc. for finding suitable alternative protein source although there have been some researches already done in this area. Soyabean *(Glycine max)* meal being a very good source of dietary protein, fatty acids (18:2 n-6 and to a lesser extent 18:3 n-3) has fairly good acceptance by different fish species[33]. It, however, contains quite a number of endogenous anti-nutritional factors standardised procedure for their removal or biological inactivation will be useful for large scale use of soyabean meal in fish/prawn feed.

ii) Poor quality ingredients having low digestibility values result in decreased availability of nutrients to fish and to increased excretion of metabolic waste products contributing towards pollution of ambient water. Optimal use of high energy diets has been shown in pilot scale experiments to increase productivity and decreased organic matter and nitrogen discharge. these aspects particularly manipulation of dietary protein : energy ratio need comprehensive studies to develop low pollution feeds for achieving sustainable aquaculture production from freshwater areas.

iii) Since nutritional quality of diets (nutrient profile, presence of anti-nutritional factors, particles size, texture, digestibility, attractability etc.) is known to have profound effects on gonadal growth and fecundity in species like rohu, mrigal, catla, silver carp etc. studies on aspects of broodstock nutrition is of utmost importance for reproduction and multiple breeding to ensure year round supply of fertile eggs of high quality. More systematic research is required for further advancement of fish production.

iv) It is utmost importance to estimate quantum of daily using nutritional energetics approach and then feed should be dispensed appropriately by hand or mechanical device at pre-determined amounts and well apaced time intervals. Different types of feeding equipment, available now, can lead to saving in feed cost through well planned feeding management as the amount of feed not actually consumed by the fish can be significant and depends not only on the physical characterstics but on the way it is fed. Improved feeding technology can reduce pollution in a similar way as high energy and low/medium protein feed does.

v) The use of probiotics in poultry and livestock diet have proved beneficial, some preliminary work has been done in aquaculture also. More research on its use in aquaculture particularly during larval rearing when mortality is high would be necessary to infer the effects of probiotics on the nitritionof fish. again at this studies on identification of feeding stimulants/attractants that evoke more active feeding behaviours are crucial application in larval feeds development particularly during the stage of weaning from live food to inert feed.

vi) Unlike marine fishes, cultured freshwater fishes contain very small amount of long chain poly unsaturated fatty acids of n-3 type particularly 20:5 (n-3) and 22:6 (n-3). These are implicated in lowering plasma triglyceride/cholesterol level and therefore reducing thrombic tendecies in man. Studies should that fish feed enriched with a blend of fish oil/ veg. oil can improve the nutritional value of freshwater fish in respect of the fatty acids making the freshwater fish more nutritius and more beneficial for human bath. There should be more studies on such value addition components in freshwater fish feeds for quality fish production.

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FEEDING OF ZOO ANIMALS

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The animals wandering in the jungles in their natural habitat search and eat food as per their requirements. They have a natural instinct that guides them to select food best suited to them. Sometimes there is abundance of food materials and the animals can afford to be choosy. But most of the times they have to toil and search for food. Under extreme circumstances, they may have to settle for something, which does not form their natural food. It is under these circumstances that cases of health problem due to food poisoning/shortages do occur. A classical example is the 1981 disaster at Ranthambhore zoological park, where hundreds of antilopes, deer etc. died due to paramphistomiasis, following acute water and subsequent feed shortages forcing them to herb near a small water pond[1]. When these wild animals are brought to the zoos, they have no longer freedom to search and select food of their choice and it becomes the responsibility of the management to provide them suitable and adequate food.

Like domesticated animals, the wild ones are also carnivorous, herbivorous and omnivorous. The job of the keeper is much simpler in the case of carnivorous animals where only required quantity of flesh is to be fed. It is more difficult to prescribe diet for herbivorous or omnivorous captive livestock. The feeding schedules followed in some zoos are given as appendix.

Most of the knowledge about the type and quantity of feed to be given to a wild animal under captivity is based on the experiences of wildlife wardens and hunters. Very little systematic work appears to have been conducted in this area. The oldest work appears to have been conducted about a century ago during 1870s and 1880s by ornithologists and entomologists[2]. In 1985 USDA instructed to initiate the study of interrelation of birds and agriculture, an investigation of food habits and migration of birds in relation to both insects and plants[2]. Most of this work was limited to studies on food habits, which gave information about what was eaten and very little about how much was eaten or what was the physiological role or importance of the ingested food[3]. Wildlife researchers in those days rarely invited collaboration with animal nutritionists. However, lately some interest has developed and studies to investigate intake or requirements of water, minerals etc. have been conducted. The work on protein and energy requirements has also been started more so after the bioenergetic investigations[4,5].

Presently in formulating rations for wild animals under captivity, guidance is being taken up from the knowledge about the similar domesticated livestock. But this too is possible in very few cases and for majority of animals, information derived from experiments on entirely different kind of livestock is extrapolated. The major problem in studying the feeding habits or requirements of livestock is that of restraining them. In the first place it is hardly possible to tie these and if at all these are tied, the results are likely to get altered. However, some work has been done at Indian Veterinary Research Institute, Izatnagar and the same is summarized below.

In an experiment voluntary feed intake of adult black buck (*Antilope cervicapra*) fed either oats or berseem fodder has been worked out[6]. It has been reported as 2.2±0.1 kg/100 kg b. wt. or 50.3±2.5 g/kg $W^{0.75}$ on oats fodder and 3.5 ±0.2 kg/100 kg b. wt. or 81.7±3.6 g/kg $W^{0.75}$ on green berseem fodder indicating that berseem was liked more than oats by this species. However, both fodders appeared to be good feeds for captive black bucks. Chemical composition and digestibilities of the two fodders are presented in table 1.

Table1. Chemical composition, mean digestibility and nutrient contents of oats and berseem fodders (% dry matter basis)

Nutrient	Oats		Berseem	
	Composition	Digestibility Coefficient	Composition	Digestibility Coefficient
DM	14.9	64.9	12.2	74.5
OM	89.1	70.0	86.1	79.2
CP	13.4	67.4	20.1	73.3
EE	2.8	55.9	2.8	69.7
Total Carbohydrates	72.9	72.5	63.2	81.6
NDF	55.3	58.8	47.3	66.2
ADF	36.8	45.5	39.0	64.8
DCP	-	9.9	-	14.7
TDN	-	69.2	-	71.3

A perusal of the above table reveals that the nutrient digestibilities and the DCP value were generally better for berseem than for oats, whereas, TDN values were comparable. It has been concluded that oats at pre-flowering stage may require some concentrate supplementation and berseem may require some high energy feed or low protein fodder.

Table 2. Chemical composition of fodder and digestibility of nutrients in black buck (% on dry matter basis)

Constituents	Chemical composition	Digestibility coefficient
Dry matter		69.49
Crude protein	10.33	72.35
Ether extract	1.53	63.60
Total Carbohydrates	74.17	72.41
Total Ash	13.97	-
NDF	64.54	70.98
ADF	39.08	56.26
Hemicellulose	25.46	83.96
Cellulose	32.42	78.40

In another experiment green maize (milk to dough stage) was fed to black buck and digestibility of nutrients worked out[7] (Table 2). Dry matter intake in this case was 2.25 kg/100 kg b. wt. or 52.54 g/kg $W^{0.75}$. This is generally comparable to values observed for oats fodder feeding to black bucks.

To get an insight for the happenings in the rumen a few studies have been conducted[8]. Status of ciliate protozoa in the rumen of black buck has been studied on fodders like oats or berseem and the results are given in Table 3 and 4.

Table 3. Total and differential counts of ciliate protozoa in the rumen of black buck fed on green oat and berseem

Protozoa	Diet	No. of Protozoa (10^4/ml) Time after feeding (h)						
		0	2	4	6	8	24	Average
Total	Oat	30.79	35.85	41.75	42.20	40.23	32.36	37.18
Protozoa	Berseem	37.99	47.17	48.55	60.50	59.70	37.92	48.64
Total	Oat	3.27	6.32	6.53	6.33	6.14	3.42	5.34
holotrichs	Berseem	3.57	9.56	8.68	11.84	10.98	3.93	8.09
Isotricha	Oat	1.83	2.43	2.47	3.08	2.97	1.91	2.45
	Berseem	1.34	2.47	1.82	2.38	2.86	1.43	2.05
Dasytricha	Oat	1.44	3.89	4.06	3.25	3.17	1.51	2.89
	Berseem	2.23	7.08	6.86	9.46	8.12	2.51	6.04
Total	Oat	27.55	29.53	35.19	35.89	34.01	28.86	31.84
spirotrichs	Berseem	34.41	37.60	39.88	48.68	48.74	33.98	40.55
Large	Oat	3.23	3.61	4.76	4.98	5.48	3.05	4.19
spirotrichs	Berseem	3.61	3.32	2.63	4.20	4.88	3.93	3.76
Small	Oat	24.32	25.92	30.43	30.90	28.54	25.81	27.65
spirotrichs	Berseem	30.80	34.29	37.26	44.88	43.85	30.05	36.79

**Each value is an average of five separate observations and each observation is an average of the protozoal count in 30 microscopic fields (magnification x 100)*

Table 4. Average number and cell mass of ciliate protozoa in the rumen of black buck fed green oat and berseem

Prtotozoa	Diet			
	Oat		Berseem	
	%	Total mass	%	Total mass
Isotricha spp.	6.59	40.00	4.21	35.44
Dasytricha sp.	7.77	2.39	12.42	5.06
Total holotrichs	14.36	42.39	16.93	40.51
Large spirotriches	11.27	48.06	7.73	45.89
Small spirotriches	74.37	9.85	75.64	13.61
Total spirotriches	85.64	57.91	83.37	59.49

It has been observed that holtrich protozoa represented mainly by Isotricha and Dasytricha were present in the rumen of black buck. Their numbers increased suddenly during the first two hours of feeding probably to the fact that the chemical stimuli originating from diet caused migration of protozoa from the wall of reticulum. This stimulus appears to have been of higher intensity on feeding berseem than oats. Though their number was in small proportion, their cell mass was significant, which indicated that holotrichs, though in small numbers, have a significant role in the digestion of feed in the rumen.

Activities of various enzymes in the rumen liquor of black buck fed on maize fodder were estimated[7] and the data are presented in Table 5.

Table 5. Mean enzyme activities in the rumen content of black buck after 4 h of feeding (Units/100 ml rumen liquor)

Enzyme	Cellular	Extra cellular	Total
Carboxymethyl cellulase	11.60±1.77	0.70±0.23	12.30±1.64
Xylanase	26.11±2.63	7.02±1.45	33.11±2.25
α-amylase	23.44±2.89	-	23.44±2.89
ß-glucosidase	5.81±0.89	0.40±0.12	6.21±0.90
Protease	68.52±9.28	5.20±2.43	73.72±6.96
Urease	1.66±0.78	-	1.66±0.78
Aspartic transaminase	2.46±0.73	0.24±0.07	2.69±0.78
Alanine transaminase	1.67±0.50	-	1.67±0.50

Mean activities of some hydrolytic or proteolytic enzymes were lower probably due to lower DCP and higher crude fibre in the fodder.

Similarly, enzyme activities in rumen liquor of black buck were estimated on sole feeding of oats or berseem (Table 6). These were found to be better indicator of ruminal microbial activities for feed evaluation[9].

Table 6. Production of cellular enzymes in the rumen of black buck fed green forages

Enzyme	Diet	Enzyme activity υ/100ml SRL	υ/mg protein
Carboxymethyl cellulase[a]	Oat	27.71	0.061
	Berseem	19.93	0.059
Xylanase[b]	Oat	43.51	0.102
	Berseem	20.77	0.062
Amylase[a]	Oat	43.20	0.130
	Berseem	39.99	0.115
ß-glucosidase[c]	Oat	12.56	0.030
	Berseem	12.34	0.036
Protease[d]	Oat	73.09	0.183
	Berseem	43.27	0.127
Urease[e]	Oat	2.71	0.007
	Berseem	3.03	0.009
Aspartic transaminase[f]	Oat	2.28	0.006
	Berseem	4.00	0.011
Alanine transaminase[f]	Oat	2.37	0.006
	Berseem	2.45	0.007

a, 1 unit = 1 μ mole glucose produced/min.; b, 1 unit =1 μ mole xylose produced/min.; c, 1 unit =1 μ mole p-nitrophenol produced/min.; d, 1 unit =1 mg casein hydrolysed/h.; e, 1 unit =1 μ mole ammonia production/min.; and f, 1 unit =1 μ mole pyruvate produced/min.

In yet another study[10] rumen cannulated black buck was fed either 250 g, or 500 g T-1/T-2 crushed maize grain along with berseem fodder. Mean activites of different enzymes and biochemical changes in the rumen liquor are presented in the tables 7 and 8.

Table 7. Enzymes activities (units/mg protein) in the rumen liquor of black buck at 4 post feeding

Enzymes	Treatment-1	Treatment-2
Carboxymethyl cellulase	0.21±0.025	0.24±0.02
Xylanase	0.05±0.01	0.23±0.02
υ-amylase	0.47±0.04	0.36±0.03
ß-glucosidase	0.10	0.11
Protease	0.48±0.08	1.88±0.24
Urease	0.04	0.14
GOT	0.02	0.04
GPT	0.04	0.013

Table 8. Effect of maize grain on biochemical characteristics of rumen liquor of black buck

Parameters	Maize grain (g)	Hours after feeding 0	2	4	6	8	Average
pH	250(T_1)	7.1	7.0	6.7	6.8	6.9	6.9
	500(T_2)	7.2	6.9	6.6	6.5	6.4	6.7
TVFA	250(T_1)	4.81	7.64	9.15	9.33	9.81	8.15
(mmol/dl)	500 (T_2)	8.50	12.83	12.54	11.61	15.32	12.16
NH_3-N	250(T_1)	29.93	33.10	31.62	25.97	36.55	31.43
	500 (T_2)	43.71	35.99	28.45	29.01	32.94	34.02

As compared to the previous study, carboxymethyl cellulase activity increased substantially, whereas effect of quantity of maize grain was not observed. However, maize grain level significantly influenced the xylanase, protease and urease activities. Maize grain level also influenced the VFA production rate and in turn the pH of the rumen liquor but not ammonia N concentration. Ciliate protozoa number in the rumen liquor was also affected by maize level in the diet. The results of experiments conducted on black buck in captivity, indicate that most of the rumen characteristics like enzyme levels, digestibility of various nutrients and intake of feeds are comparable with domestic small ruminants. This is also confirmed by the voluntary feed intake of different feeds and fodders tested in these experiments. Therefore, the conventional feed materials, which are commonly used for the feeding of domestic ruminants, can be included in the feeding schedule of black buck without any adverse effect and the level of feed intake is much higher than the maintenance requirement of these animals. But we may not be so lucky with the other wild animals and individual feeding experiments are essential before reaching any conclusion. Thus, there is a great need for conducting planned experiments on different wild animals kept in zoos to understand their feeding behavior and nutritional requirements.

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APPENDIX
Scale of feed of various animals and birds for zoos.

ANIMALS

Sl. No. 1	Name of species 2	Kind of feed 3	Feed/day/Animal (kg) 4
1	Tiger-Adult	Buffalo Meat	11.000
	Tiger-Semi Adult	-do-	05.000
2	Lion -Adult	-do-	11.000
	Lion -Semi Adult	-do-	05.000
3	Leopard-Adult	-do-	04.000
	Leopard-Semi Adult	-do-	03.000
4	Wolf	-do-	02.000
5	Hyaena	-do-	03.000
6	Jackal	-do-	01.000
7	Golden Cat	-do-	00.750
8	Leopard Cat	-do-	00.750
9	Jungle Cat	-do-	00.750
10	Civets	-do-	00.750
11	Fox	-do-	00.750
12	Ratel	-do-	02.000
13	Crocodile	-do-	01.000
14	Indian Gavial	Fish	01.000
15	Honitor Lizard	Buffalo Meat	00.250
		Milk	00.125
16	Varanus Species	-do-	00.250
			00.125
17	Caracal	Goat Meat	02.000
18	Otter	Fish	01.500
19	Mongoose	Buffalo Meat	00.125
		Milk	00.125
20	Slender Loris	Boiled Egg	2 Nos.
		Bannna	00.125
		Milk	00.125
21	Slow Loris	-do-	2 Nos.
			00.125
			00.125
22	Wild dog	Buffalo Meat	01.000
	Pangolin	Egg	1Nos.
		Milk	00.250
		Ants & Insect	00.050
23	Hedge Hog	Milk	00.250
		Banana	00.125
24	Porcupine	Gram	00.125
		Maize	00.125
		Veg. Fruits	00.250
		Ground nut	00.050

25	Bear	Milk	02.000
		Wheat flour Bread	01.500
		Veg.& Fruits	00.250
		Gud or Gudia Shakar	00.125
	Wild Boar	Dana Chana	01.000
		Green Fodder	06.000
		Veg. Fruits	00.500 Seaonally.
26	Yorkshire Pig	Dana Chana	01.000
		Green Fodder	06.000
		Veg. & Fruits	00.500 Seaonally
27	Fallow Deer	Dana Chana	00.500
	Spotted Deer	Green Fodder	05.000
	Hog Deer	Veg. & Fruits	00.500 Seaonallly
28	Sambhar/ **Blue Bull**	Dana Chana	01.000
	Water Buck	Green Fodder	06.000
		Veg. & Fruits	00.500 Seaonallly
29	Barking Deer/ Chinkara/ Four Horned/ Antelope	Dana Chana	00.400
		Green Fodder	04.000
		Veg. & Fruits	00.500 Seaonallly
30	Kangaroo	Fruits & Veg.	00.500
		Green Fodder	01.000
		Bread Slice	4Nos.
31	Rabbit/Guinea Pig	Dal Channa	00.200
		Green Grass	00.100
32	Tortosie/white Mice	Boiled rice	00.100
	Turtle	Milk	00.125
33	Python	Fowl/Rabbit	1Nos.
		Duck/Pigeon	Once A **week.**
34	Giant Squirrel	Fruits & Veg.	00.125
		Groundnut	00.100
		Roasted Gram	00.100
35	Chimpanzee	Fruits	01.000
		Bread Slice	6Nos.
		Milk	01.000
		Tea	2cup.
		Boiled Egg	1Nos.
		Onion and Garlic	00.100
36	**Mandrill/Baboon Drill**	Fruits	00.500
		Bread Slice	4Nos.
		Vegetable	00.250
		Milk	00.250
		Roasted Gram	00.100
		Boiled Egg.	1Nos.
37	Capuchin/Spider Red-Patas-Sooty Mangabey, Douroucouly	Fruits & Veg.	00.500
		Bread Slice	2Nos.
		Milk	00.250
		Roasted Gram	00.050
		Boiled Egg.	1Nos.

38	**Gibbon Monkey**	Fruits &Veg.	00.750
		Boiled Egg	2Nos.
		Milk	00.250
		Bread Slice	2Nos.
39	*Lion Tailed Monkey/*	*Fruits & Veg.*	*00.500*
	Stump Tailed monkey/	Boiled Rice	00.125
	Bonnet Monkey/	Milk	00.250
	Rhesus Monkey/	Bread Slice	2 Nos.
	Nilgiri Langur/	Groundnut	00.100
	Pig Tail Monkey/	Roasted Gram	00.050
	Ganed Langur/		
40	Losser Panda/	Horlicks	00.025
		Oat Powder	00.025
		Bamboo Leaves	00.500
		Fruits & Veg.	00.100
		Milk	00.500
		Wheat Flour	00.250

BIRDS

Sl. No.	Name of species	Kind of feed	Feed/day/Bird (g)
1	White Peacock	MixGrain	250
	Indian Peacock	Green Veg.	125
		Mesh	050
		Onion & Garlic	050
2	Golden Pheasant	Mix Grain	050
	Silver Pheasant	Vegetable	025
	Lady Amhorsts	Mesh	025
	Swin Hoo's	Onion & Garlic	025
	Jungle Fowls		
	Kalcej Pheasant		
	Peacock Pheasant		
3	Red & Blue Macaw	Mixed Grain	100
	Yellow & Blue	Fruits &Veg.	100
	Macaw/Cockatoos	Groundnut	025
	African Grey Parrot	Onion and Garlic	010
		Sunflower Seeds	010
4	Emu/Rhea	Gram & Maize	500
		Veg. & Fruits	*250*
		Onion & Garlic	125
		Wheat Flour Bread	125
5	Ostrich	Gram & Maize	000
		Fruits & Veg.	500
		Onion and Garlic	500
		What flour Broad	250

6	Large Indian Parrot/ Rose Ringed/Slaty Headed/Bloossom Headed/Blue Winged/ Indian Loorikeet Malayan Loorrikeet Mollucan Loorrikeet Jendaya Conures	Dhan Mixed Grain Fruits & Veg. Groundnut Boiled Rice Green Chillies	010 020 025 010 010 010
7	Budgargar/African Love Bird/ Zebra Finch/ Golden Finch/Green Finch/Red Munia/ Spotted Munia	Kangani Seed Millet Green Veg.	010 010 025
8	Sobia/Cannaries Bunting/Skylark Minivet/Wheaver Bird/Java Sparrow/ Piddi	Millet Green Veg. Kangani	025 025 010
9	Rufous Turttio Dove Ring Dove/Spotted Dove.	Millet Green Veg.	050 025
10	Grey Partridge/Black Partridege/Rain Quail Chuker/Sandgrouse	Millet Green Veg.	050 025
11	Pigeon Various Species	Millet Green Veg.	100 010
12	Guinea Fowl/Turkey Poultry Bird	Millet Green Veg. *Onion and Garlic* Minced Meat	150 025 *025* 010
13	Pochard/mallard/ Pintall/Spotbill Surkhab/Comb Duck/ Shoveller/Teal/ Wigcon/Murgabi/ Coot/Moorhen/ Mucovey/Localduck.	Millet Green Veg.	100 015
14	Barhead Goose/Grey Lag Goose/Pink Footed Goose/ White Fronted Goose/Red Breasted Goose/ Common Goose.	Millet Green Veg. Wheat Flour Bread Onion and Garlic	150 050 050 025
15	*Flamingoes*	*Millet* Green Veg.	*200* 050
16	Sarus Crane/ Common Crane/ African Crane Kulang & Crane Demoiselle Crane Crowned Crane/ Eastern Crane	Mash Green Veg. Wheat Flour Wheat Flour Bread Gram & Maize	050 150 050 050 150

17	Chugga (mash) Eaters White Creasted Laughing Thrush White Throated Blue Jay/ Roller Treepi/Red billed Blue Magpic/ Wishtling thrush/ Robin/Myna/Koel Black Drongo	Mash Boiled Rice Fruits & Veg.	025 010 020
18	Painted Stork/black Necked Strok/white Stork/Adjutant Stork Spoenbill/White Ibis/ Black Ibis/ Egert/Heron/ Darter Openbill Stork Black Stork	Fish Minced meat	250 250
19	Pelicans	Fish	250
20	Sandpiper/Curlew Lapwing/Ships/Stilt/ Ruff & Reave	Millet Green Veg.	020 010
21	Bustard/Florican	Millet Green Veg. Meat	200 050 250
22	Horn Bill	Fruits & Veg. Maize/Gran Boiled Egg	250 050 1

* Rock Salt and Mineral Bricks have to be supplied for carnivorous and herbivorous animals as per requirement.

YAK AND ITS PRODUCTIVITY

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Yak (*Poephagus grunniens L*) is a multipurpose bovid of the high altitudes of Central Asian countries. Its natural habitat is in between 3000-6000 msl in the countries situated in the southern phase of the Himalaya and at a lesser altitude in the north and north western side. The countries in the North of Himalaya are China, Tibetan plateau, Mongolia, Tuva, Buryat, Tajikistan, Kajikistan and Russia. The Himalayan countries inhabiting yaks are Pakistan (Hunza region and Gilgit). India (Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh, Sikkim, and Arunachal Pradesh) Nepal and Bhutan. These countries account for approximately 1 percent of the world yak population of 13.7 million. Peoples Republic of China is credited to have maximum population (13 million) followed by Mongolia (0.5 million) (Table 1).

In India, Arunachal Pradesh, Sikkim, Uttar Pradesh, Jammu & Kashmir and Himachal Pradesh account for 8500, 5350, 310, 22000 and 3500 heads respectively and is presented in Table 2 (Pal, 1993; Pal & Madan, 1996). This population is the surviving popultion out of 1,32,000 reported four decades ago (Pal, 1993a). The drastic reduction in population in the last few decades had its adverse effect on the economy of the highlanders, who primarily subsist on the animal husbandry resources, as very little agriculture exists in the high alitude.

Table 1. Yak Population in different countries.

Countries	x1000 Heads	Reference
China	1292	Cai Li and Gerald Wieiner, 1995
Mongolia	571	Cai Li and Gerald Wieiner, 1995
Russia	60	Sabagishav, *et. al.*, 1989
Tuva	32	Sabagishav, *et. al.*, 1989
Tajikistan	17	Sabagishav, *et. al.*, 1989
Kirgizia	60	Katzina, 1995
Altai	16	
Buryatia	07	
North Caucasus and Yakaia	Introduced in 1970	
India	40	Pal and Madan, 1996
Nepal	9	Joshi *et. al.*, 1994
	19	Paudyal, R.M. 1993
Bhutan	52	Bonnemaire, 1984; Manson, 1987
	30	Cai Li and Gerad Weiner, 1995
Pakistan	1	Kreutzmann, H., 1986
	25	Ashiq and Abdul, 1995
Afganistan	Figure not available	

A similar trend in the decrease in the number of yak population has been reported from other countries specifically from Nepal, Bhutan and Pakistan (Masao Sasaki, 1994). Mongolia has recorded an increase in yak population in the last one decade. *The other agonising fact is the drastic reduction in the population of wild* yak (*Poephagus mutus* L). Wild yaks are found only in Qinghai Tibetan plateau and in the Kunlun Mountains and the present population is estimated to be 20-40 thousand (Lu & Li, 1994), Another estimate put their number at 15 thousand (Miller *et. al.*, 1994). Wild yak has been declared as an endangered species in China.

In the preceding paragraphs, some of the most important facts and attributes of yaks have been presented.

NOMENCLATURE

Yak has been nomenclated *Bos grunniens* (Linnaeus, 1758) *Vacca grunniens villora, Cauda equina* (Gmelin 1760), *Tartary cow* (Buffon, 1767) *Bos poephagus, Bos grunniens* of Pallas (Aelianus Cladius, 170-235 AD) *Bison poephagus* (Jordan, 1836), *Poephagus grunniens* (Gray, 1843; 1846; 1852) *Poephagous grunniens* (Olsen, 1991). Pal (1996) argued that the observation and reasoning advanced by Olsen (1991) in his explorative and palentological work should be accepted and yak should be zoologically nomenclated as *Poephagous grunniens* only. The first International Congress on yak took a decision to this effect.

Table 2. Yak population in different states of India

States	Districts	Male	Female	Total
Arunachal Pradesh	Tawang	2648	4205	6853
	West Kameng	580	799	1379
	Upper Subansiri	117	131	248
Sikkim	North	-	-	4865
	East	-	-	40
	West	-	-	441
J & Kashmir	Laddak (Leh Kargil)	6003	9733	15736
	Srinagar	81	62	143
	Doda	4395	1131	5526
Himachal Pradesh	Kinnur	544	413	957
	Lahaulspiti	1457	522	1979
	Chamba	915	1450	2365
Uttar Pradesh	Pithoragarh			102
	Uttarkashi			175
	Nainital & Chamoli			041

ACCLIMATIZATION

Yaks have developed specialized adoptive measures for high altitude living where low temperature (Min - 50°C), low atmospheric (398 to 468 mm Hg) and oxygen pressure (52.4 to 61.5 mm Hg) are common. Low level of nutrient availability, specifically in the winter is the 3rd stress. To counteract cold temperature it swathed itself with a undercoat and developed a subcutaneous fat layer. Besides decreased basal metabolic rate and constriction of the superficial blood vessels. To over come low oxygen environment it has a bigger heart contributing to counteract hyppxia. Yu and Yang (1997) while comparing the gross anatomy of yak heart with yellow cattle have observed that right and left ventricle are much well developed. Recently, Sarkar *et. al.*, (1997) has come out with an observation that the foaetal haemoglobin is more in yak calf and adult yak in comparison to other animals, a measure to arrest asphyxis. To counteract low oxygen pressure yaks respire less number in winter coupled with low lung volume/min., absorb more oxygen (cm^3/min.) and expel more CO_2 (cm^3/min.) with high RQ in comparison to data when they are put to high environmental temperature (Gansukh, 1997). The pulmonary vasoconstrictor factor causing hypoxic condition has been eliminated as genetical adoption for high altitude living (Anand *et al.*, 1988). The animals in the winter loose 20 to 30% of their body weight. In the reproductive area, acclimatization has been affected by reducing gestation period (258 days), less calf birth weight (8-15 kg) and less lactation period (150-200 days).

BREEDING AND CROSSBREEDING

Based on the phenotypic characters, in India five types of yaks has been categorised (Pal *et al.*, 1994 & 1995). Wild yaks bulls are used to breed the domestic yaks. The new born calves are found to be 30% heavier, and by 50% at 6 months (Lu Hongji *et. al.*,1987). Body size, hair and meat output and milk yield were reported to be higher in F-1 (Wild Yak x domestic yak cross, (Lu & Li 1994). In India, they are bred at random without any specific plan and programme. Inbreeding in small pockets is random as the same bull is used consecutively for two or three generations. Crossbreeding with cattle is common. The F-1 females are good milk yielders, the males are sterile but show heterosis in their growth (Pal, 1992).

NUTRITION AND PASTURE MANAGEMENT

The nutrition and pasture management in the high altitude is the most complicated, least heeded by the yak herdsmen and also by the researchers till date. The approximte availability of alpine pasture in India has been reported by Pal and Basu (1994). The pasture land and the occassionally cultivated land in the mid altitude are heavily infested with weeds (Basu *et al.*,1992). Which decrease the availability of fodder. Yak are grazed in the summer (April to October) in the alpine region, where the availability of grass and congenial climate is in abundance. During this period the yaks not only regain the lost weight during winter but also put additional weight. The productivity of milk is in peak (Pal and Madan, 1996). Introduction of exotic grass species, *Dactylis glomerata* has given good results. Oats (var. Kent) has also proved good persistantsy. Fodder trees, *Salyx humboldtiana* and *Salyx babolicana* proved successful in the mild altitude (Annon, 1994-95). Conservation of grass residues and post harvested maize plant for winter use were helpful to raise yaks in the winter with almost no weight loss. Farmers are becoming increasingly conscious about the need to conserve and preserve the fodder for winter use. Reproduction related trace elements like Copper, Cobalt and Zine were found to be optimum in the alpine grazed yak exhibiting normal reproductive behaviour. Yaks grazed in winter pasture at lower altitude showed almost one third of the alpine values of Cu, Co, Zn followed by inefficient reproductive performance (Mohanty, 1996).

REPRODUCTION

The reproductive cycle of yak by and large is similar to cattle. The reproductive life is 15-16 years in female and 5-9 years in male. Yaks are generally seasonal breeders and calving occurs once in two years or twice in three years though annual breeders are not uncommon. Delayed sexual maturity and long post-partum period is the main cause of low reproductive efficiency in yak. The female reproductive organs viz. cervix structures, corpous uteri and long uterine septum are different from cattle, though the histological structures are similar (Qiu and Zhu 1981). The male organs are compartively smaller in size. The penile length, scrotal circumferance and diameter is smaller than cattle. The glans penis is blunt, the most significant diffence from cattle. The correlation (r) between cotyledon size and number with calf birth weight in yak is significantly higher than in cattle. Cotyledon size, number and calf birht weight are considered to be acclamitization measures. The ovary and the corpuslutea in pregnancy is not easily palpable due to small size (Mohanty 1996). Abortions due to infectious diseases and plant toxicity are prevalent.

DISEASES

Yak has capacity to counteract cold climate, low oxygen and low nutrition level. As regards disease, it is equally vulnerable like other bovids. Pal (1993) has reviewed the diseases found in yak in different countries. More recently Lench and Geilhausen (1997) and Joshi *et. al.*, (1997) reported the infectious and parasitic diseases encountered in yaks. In some pockets namely Bhutan, gid or staggering disease in yak calves takes a heavy toll. Both ecto-and endo-parasites and leeches play havoc with yak in summer season (Biswas, *et al* 1994) at mid altitude. Occasionaly toxic plants in the grazing ground, specific mention could be made of *Senecio sp* cause death in herds (Mondal *et al.*, 1997; Winter, *et al* 1990).

MILK PRODUCTION

Yaks in wilderness produce as muck milk as is required by the suckling calf for a limited period to avoid excess draining out of nutrients through milk. The same trait is still existing even after domestication. Acclimatization for high altitude living may also necessitated the need to produce less milk for a short duration. The milk yield data reported in different countries is presented in Table 3. The milk yield is greatly influenced by the nutritional status of the cow. Suckling is common as they do not letdown milk unless suckled by calf. One time milking (morning) is common. Yak female when calved early in the season (March) have longer lactation period. Raw milk is not extensively used as drink except for sick and old people. It is converted into butter and cheese.

Table 3. Milk yield in yaks

Country	Milk Yield/day (kg)	Lactation Period (days)	Total yield (kg)	Fat%	Ref.
China	(1.54)	165	346	6.4	Cai Li, (1985)
	(0.9-2.56)	(150-210)	(3092-385)	(5-7-6.8)	
Mongolia	2.20	255	738	7.2	Bat Erdene (1996)
	(1.0-3.8)	(210-300)	(563-738)	(6.0-11.4)	
	2.6	245	645	7.3	*Tumujev, (1995)*
	(1.0-3.8)	(171-331)	(382-1018)	(6.28.0)	
		265			
USSR		(82-388)	(858-1066)	(5.3-8.6)	Sarbagishev *et. al.*, (1989)
India	-	270	-	-	-
		(260-300)	(500-700)	(8.9)	Katiyar *et al.*, (1982)
	(1.0 to 2.0)	(90-215)	(129-281)	(6.5)	Jain & Yadav (1985)

Local cheese (churpi) is made from the fat extracted curdled milk after heating in the hearth and then separting the solid mass. The material free of water is then preserved in a skin bag. An estimation of bacterial load on different cheese samples revealed presence of 28 types of bacteria, 8 types of fungus (Pal *et al.*, 1996). With this indigenous technology, the cheese has very little market value. In Nepal the yak cheese manufacture technology has been perfected and they produce annually 102 Mt of cheese earning more than US $ 49400, (Thapa, 1997). The other products made from yak milk are "Toffee", "Milk Residue"; "Milk Cake"; sour milk and whey, the later mostly is used for feeding pigs or in traditional processes for making leather.

MEAT

Yak meat is an important source of nutrient to the yak herdsman and others in all the yak rearing countries. In India, yaks are slaughtered not as a routine, but only to meet the festive and religious requirements. Mostly old and non productive yaks are slughtered for meat purposes. Yaks are considered to be best for meat purpose just before the onset of winter when then are prime in their health. Yaks are slaughtered in China and Mongolia in abbatoir but in India they are simply strangulated to last breath in open place followed by slicing off the jugular vein to drain and collect the blood, to make palatable dishes out of collected blood. Yak meat in comparison to beef is more tender, juicy and well flavoured. It has less or no marbling in the meat and is called as red meat for its intense scarlet colour due to presence of high myoglobins. Yak meat has been priced more than cattle since ancient times. The dressing percentage is influenced by age and sex and season of slaughter and varies from 37.6 to 56.2 percent. Medium aged animals give the best dressing rate (Cai Li and weiner, 1995). The average protein and fat content in yak meat varies from 20.0 to 22.3 and 1.4 to 11.9% respectively, where as in beef the corresponding figures are 13.7 to 27 and 6.4 to 30.0% (Oser 1954). The different meat products are Air Dried Meat and Sausage.

Table 4. Projected yield of yak fibres in the yak rearing countries

Country	Finewool[a] Undercoat (ton)	Coarse hair[b] (ton)	Tail (Lakhs)
India	16	40	0.2
China	4800	48000	60.0[c]
Mongolia	228	2284	3.0
Countries of,			
Russian Fed	24	240	0.3
Kazakistan	24	240	0.3
Tajakistan	8	80	0.1
Nepal	8	80	0.1
Bhutan	12	120	0.2

a. Approximate yield 0.4 kg/ Animal/year.
b. Approximate yield 4.0 kg/Animal/year.
c. China has already started marketing the product.

UNDERCOAT AND HAIR

Yak produces two types of hairs, the guard hairs are coarse, long and lusturous (grow even beyond 20 cm) and the down fibres are fine and soft. The length of the coarse and fine hairs were found to be 1992 and 80 mm (Pal, 1994, Unpublished data). The more is the severity of cold, the greater is the yield of the fine wool. Unlike the sheep wool, the yak hair is medulated. The skin, fresh as well dried is being utilized locally (bags, coracle, tent etc.) but commercial tanning has recently been taken up by Chinese Cooperatives. Scheller (1993) observed that the leather made from Yak hides for shoes, leather goods and clothing is characterised by an interesting grain pattern and good wear performance properties.

Table 5. Expected economical return provided proper marketing avenues are available (in US $) from hairs and wool

Countries	Fine wool[a] Undercoat	Coarse hair[b]	Tail flywhiskers[c]	Total
India	48	80	60	188
China	14400	96000	18000	128400
Mogolia	674	4568	900	6142
R. Fedeoration	72	480	90	642
Kazakistan	72	480	90	642
Tajakistan	24	40	30	94
Nepal	24	40	30	94
Bhutan	36	240	45	321
Total	15350	101928	19245	136523

a. 3000 US $/ton.
b. 2000 US $ /ton.
c. 3000 US $ /ton.

PACK AND TRANSPORT

Yak is well known capabilities to move in the high altitude with pack. Its hoof with a better grip characteristics aids it to negotiate the steep hills. On marshy land yaks with load easily waddle and cross the area. Generally yaks with 50 to 60 kg load move for 6 to 8 hrs. with occasional rest in hilly terrain. In undulating areas as in Tibetal plateaus yak with 60 to 80 kg load can traverse 20 to 30 km per day. Maiwa yak in some cases in Sichwan Province could carry 75 kg for a distance of 30 km in 6.2 hrs. (Cai Li and Weiner, 1995). Now-a-days mountainers and Everesters use yak as pack to transport the gears up to the base camp, of approximatley 6500 msl. In India the army, paramilitary forces and mountain trackers besides the yak herdsmen depending on yak to transport rations in the forward camps. Due to load and tracking there is significant increase in the haematological values, respiration, heart and pulse which take more than 30 minutes to come to normal after the completion of the mission Mondal *et. al.*, (1997).

CONCLUSION

The multipurpose high altitude bovide has been endowed with many attributes viz. high altitude acclimatization, many of its faculties have not yet been studied for optimal exploitation. The present declining in its population should be arrested to ameliorate difficulties for the high landers whose life depend on it. The products viz milk, meat, fibre and pack are valuable commodities and processing technologies need to be upgraded to ensure better economic returns to the farmers.

Yak nutrition specially, winter feeding is required to be addressed urgently. Ecofriendly measures to augment pasture productivity, accompanied with preservation and conservation of fodders need immediate attention. Germplasm improvement by selective breeding and by introducing proven frozen semen for A.I. should be made avaliable to the farmers.

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