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Review Article

Precision Animal Nutrition (PAN): A Way to Sustainable Dairy Production

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Abstract

Precision Animal Nutrition, is to provide the animal with the feed that precisely meet its nutritional requirements for optimum production efficiency, produce better quality livestock products and contribute to the cleaner environment and thereby ensure profitability. It is to enhance the production efficiency along with production of quality produces for the end users contributing to economical and cleaner environment. The use of strategies such as accurate feed formulation, restricted use of dietary proteins, strategic supplementation of essential nutrients, use of feed additives, feeding of total mixed ration, proper monitoring of dry matter intake and feed-bunk management, use of diagnostic techniques for early detection of diseases, least cost ration formulation and manure analysis etc. will ensure the accomplishment of the objectives of precision feeding.

Keywords: Precision; Feeding; Nutrition; Animal.

Introduction

With the rise in world's human population, better economic standard, awareness on health and increase preference of animal protein had subsequently increased the demand of animal products. The consumption of animal products is expected to be about 70% higher in 2050 than what it was in 2005 (FAO, 2009) and according to another projection the demand for meat and milk is expected to be 58% and 70% respectively higher in 2050 than their levels in 2010, and majority of this increase will originate from developing countries (FAO, 2011a). To satisfy today's demand for such products; livestock sector has to greatly increase its production potential. But, with the increase in consumers concerns over safe, nutritious, wholesome, natural and quality assured food products for consumption the production of quality animal products is also the need of the day.

Apart from producing quantity and quality products the dairy enterprise should be economically viable and sustainable. With the narrower profit margins, increased fluctuations in product prices and growing environmental scrutiny, requires more accurate accounting of inputs/outputs to remain the enterprise sustainable and profitable. But, the present traditional livestock production system involves use of high inputs, presence of indiscriminate and objectionable residues in animal products that are associated with various health ailments, enteric emission and excretion of excess nutrients such as Nitrogen, Phosphorus and other compounds as manure causing environmental pollution. And the factors, such as scarcity of land and water, on going global warming accompanied with large variations in climatic conditions, increased competition for arable land and fossil fuels will further pose a great challenge to sustainability of traditional feed and food production system.

In this context, the concept of '*Precision Feeding*' that comprises effective use of available resources, inclusion of quality feeds posing minimum negative impact on environment will be a viable alternate to overcome the challenges of present animal feeding practices and to support the targeted production. '*Precision Animal Nutrition' (PAN)* as defined by Reddy and Krishna (2009) is to provide the animal with the feed that precisely meet its nutritional requirements for optimum production efficiency, produce better quality livestock products and contribute to the cleaner environment and thereby ensure profitability.

In reference, to developed countries and some intensive commercialized production system of developing countries, the precision feeding consists of utilization of high quality feed resources and ensures its consistent delivery to animals by using computerized technologies. However, these advanced automatized technologies are difficult to be implemented in developing countries due to lack of resources and infrastructure and predominance of extensive and mixed livestock production systems there. For the diverse production systems prevailing in developing countries, the term precision feeding and balanced feeding can be used interchangeably (Makkar and Ankers, 2014) as both aims to provide ration as per the nutrient requirement of animals, maintains rumen health, maximise microbial protein synthesis that overall enhances the feed efficiency. This will lead to increased productivity, reduce nutrient excretion, decrease feed cost input, enhance animal health, and contribute to cleaner, greener environment and sustainable production system.

With the growing concerns over environment, the livestock farms are focussed to reduce the manure nutrient excretion and soil nutrient accumulation. Recently, the US department of Agriculture –National Resource Conservation Service (USDA-NRCS) has identified the need to reduce manure nutrient through improved feed management on farms with animal feeding operations, and have developed a national standard (NRCS, 592) to be used as part of the nutrient management planning process (NRCS USDA, 2003). The purpose of feed management plan as mentioned in NRCS, 592 standard is

1. To supply the quantity of available nutrients required by livestock while reducing the quantity of nutrients excreted and to,
2. Improve net farm income by feeding nutrients more efficiently (Fox, et al., 2006)

The implementation of the practices outlined in New York (NY NRCS USDA, 2005) Feed Management Standard is actually the precision feeding. According to this, precision feeding is a site-specific practice that involves accurate diet formulation and delivery to each group of animals in the herd, and evaluating and improving the feeding program on a specific farm on a daily basis. To adapt the Precision Feeding program certain specific information of farm, group and individual animals must be known. The site-specific data here means, average animal body weight, production level, accurate feed requirement as per the physiological status, feed analysis and environmental factors etc. It should emphasis on delivery of the same form of ration every day to every cow, as due to profound genetic selections of feed and fodders the NRC standard nutrient composition tables may not be used for accurate ration formulations. So, feed analysis shall be conducted more often for diet adjustments. Likewise, to monitor the nutrient excreted and accumulated in the soil the manure analysis should also be done periodical.

Objectives of PAN

1. To improve the efficiency of production
2. Efficient utilization of available feed resources
3. Reducing the overfeeding and quantity of nutrients excreted.
4. Improve net farm income by feeding nutrients more efficiently.
5. Enrichment of products for the well being of the consumer.
6. Decreased emission of environmental pollutants (e.g. nitrogen, phosphorus and methane)

Effective Measures to Attain PAN

Accurate Feed Formulation

Formulation of ration should be exactly as per the requirements of animals. It is known that the actual nutrient requirement depends on;

a. *Animal Factors* (production level, genetic potential, gender, age, body weight and health status)
b. *Environmental Factor* (ambient temperature, humidity, space allowance, stress factors)
c. *Nutritional Factors* (nutrient composition, digestibility and level of anti nutritional factor)

Usually nutritionist formulate the rations as per the nutritional recommendation which often contains significant safety factors because nutritional requirements and availabilities for all types of cattle, feeds and environment or management conditions are at variance. The extra nutrients contained in these safety factors to ensure that nutrient requirements were met often increased nutrient excretion and contributed to adverse effects on water and air quality. Thus, an accurate assessment of both animal requirements and dietary nutrient supply is economically and environmentally important. Hence Cornell Net Carbohydrate and Protein System (CNCPS) have been developed to evaluate diet and animal performance.

Nutrition Model Designed for Precision Feeding: Cornell Net Carbohydrate and Protein System (CNCPS)

The CNCPS is a mathematical model developed from basic principles of rumen function, microbial growth, feed digestion and passage and animal physiology (Reddy and Krishna, 2009). It is utilized to accurately predict farm specific animal requirement, absorbed nutrients from available feedstuffs and nutrient excretion that particularly will result in optimizing rumen health to maximize forage utilization and microbial protein production. To make these predictions, feed content of carbohydrate (starch, sugars, NDF, lignin) and protein fractions (total, soluble, and unavailable, amino acid profile) and their digestion rates along with fat and ash content must be determined.

To accomplish real/accurate diet formulation feed analysis should be the part of periodic works done on the farm. Chemical analysis along with the other quick assays such as NIRS, XFS, laser and in vitro techniques can also be used for certain prediction equations.

Restricted Use of Dietary Proteins

Dairy cows utilize feed crude protein (CP) with greater efficiency than other ruminants but still excrete about 2-3 times more N in manure than they secrete in milk. This increases both cost of milk production plus environmental N pollution. Dietary CP supplies absorbed amino acids but extra CP not utilized for production is lost in the urine. Urinary nitrogen is the most polluting form of excretory nitrogen because much of it is lost as atmospheric ammonia or into surface and ground water. . In the trial by (Broderick 2003) energy density was increased by reducing forage from 75, to 62 and 50% of dietary DM, giving diets with 36, 32, and 28% NDF; dietary CP was fed at 15.1, 16.7, and 18.4% of DM at each NDF level. There was no interaction between energy density and CP level; that means that the cows responded to CP the same way at all 3 energy levels. Milk and protein yield both increased with the first CP increment, but there was no difference between production at 16.7 and 18.4% CP. There was a linear increase in N excretion with increased CP in the diet and most of the extra manure N was found in the urine. The entire incremental urinary N was excreted as urea, the form that can be quickly broken down and lost as volatile ammonia (Broderick, 2003). Overfeeding of protein actually suppress the production as 7kcal of net energy is required to convert 1 g of N to urea (NRC, 2001).

Feeding of Rumen Undegradable Protein (RUP) and Protected Amino Acids

Feeding less CP, even from high RUP sources, reduces production because microbial protein is reduced. Low soluble fishmeal and canola meal were more effective sources of RUP than heated soybean products. Supplementing rumen-protected methionine allows for some reduction in dietary CP without losing milk yield as studied by Krober et al (2000) where supplementing RP-Met to a 14.7% CP diet resulted in milk protein secretion equal to that of 17.5% CP diet, but at 31 versus 27% conversion of dietary N to milk N.

For tracking the CP content of actual diet fed, frequent sampling and analysis of feed ingredients is crucial. Monitoring Milk Urea Nitrogen (MUN) can also be used to assess both dietary CP and urinary N excretion in lactating cows and thus is a very useful technique to assess the adequacy of protein feeding. Urea is the primary form of excretory N in mammals and blood urea equilibrates rapidly throughout body fluids, including milk and MUN concentrations reflect blood urea (Rook and Thomas 1985) and equilibrium between blood and milk occurs within 1 to 2 hours (Gustafsson and Palmquist 1993). Therefore, MUN serves as a useful index of inefficient N utilization in the lactating dairy cow (Kohn et al 2002). Broderick and Clayton (1997) reported a strong relationship between dietary CP concentration, expressed either on DM or energy basis, and MUN. Urea in body fluids, including milk, results not only from excess protein degradation in the rumen but also from N inefficiency caused by excess supply of protein to the tissues.

Strategic Supplementation of Essential Nutrients

Especially in semi organized and small holding livestock production system, crop residues constitute the major source of roughage for livestock, But, as they are nutritionally poor and serve as bulk for feeding there is need to improve their nutritive value in terms of digestion and intake. Ammonia treatment through urea hydrolysis is a promising method because of simple technology and low cost involved. Ammonia treatment of wheat straw significantly enhanced the soluble phenolics by 52% and decreased the total cell wall phenolics by about 12% (Reddy and Singh 1992). The CP content was enhanced to 10.37% from 2.59 while ME content was enhanced to 1.99 Mcal/kg DM from 1.62.

Voluntary intake of feed may be increased not only by physico-chemical treatment (chopping and ammoniation) but also through enhanced rumen fermentative digestibility by supplementation of critical nutrients (Reddy 1989), which stimulates intake of feed. Inspite of promising effects of urea ammoniation of straws the technology has not been adopted well at field level. Supplementation with locally available feed resources, such as caged poultry droppings (CPD), sugarcane molasses, deoiled rice bran would help in improving feed utilization. Strategic supplementation increases the efficiency of ruminant productivity on straw-based diets (Leng 1991) and thus paves the way for developing 'environment-friendly' livestock production system.

Use of Feed Additives

Feed additives play a pivotal role in achieving increased feed efficiency by increasing digestibility of nutrients and reduced environmental load per unit of animal product. These include probiotics, prebiotics, organic acids, fibrolytic enzymes, plant extract, ionophore antibiotics, antioxidants from plant origin (catechins, flavonoids), feed emulsifiers (Lecithin, lysolecithin) that helps in better digestion and fat absorption and toxin binders (bentonite, alumina silicate), certain vitamins and minerals etc. Due to overuse and because of problem of residual effect the use of antibiotics have breed stopped in animal diet. Only certain selected and proven group of ionophores antibiotics are in current usage. Review of literature on beneficial effects of ionophores (Tedeschi et al, 2003) revealed that monensin might decrease protein degradation in the rumen and increased feed protein utilization by 3.5 percentage units. Ionophores could decrease methane production by 25% and decreased feed intake by 4% without affecting animal performance. The others ionophores such as, monensin, lasolacid, salinomycin etc are also known to regulate rumen fermentation and propionate production. The organic acids like fumarate and malate also enhance propionate production and reduce methane production. The use of exogenous fibrolytic enzyme like cellulase and xylanase increases the forage utilization and enhances the production efficiency of ruminants. Plant extracts have been conceived as potential natural alternatives for enhancing livestock productivity. Plant secondary metabolites, in some instances, have inhibiting effect on methane, which is most likely mediated through their effect on rumen protozoa, since elimination of rumen ciliates can reduce methane emission and reduce rumen proteolysis. Plant secondary metabolites such as condensed tannins may be used as organic protectant of protein from rumen degradation thus providing more dietary and microbial protein post-ruminally for production purposes. The feeding of yeast (*Saccharomyces cerevisae*) increased bacterial population and fibre degradation in the rumen leading to increased feed intake and flow of microbial protein.

It is usually not possible to meet the requirement of all minerals through feed and fodder alone for higher production. In alternate to this, providing area specific mineral mixture based on the deficiency of mineral in soil, plants and animals in different agro-climatic zones is the most appropriate and cost effective strategy of mineral supplementation. (Gowda et al, 2013). The feeding of free choice mineral supplementation is not assumed to be a good practice in terms of precision feeding, because there occurs the complex interaction among certain minerals and the excess of some may effect the utilization and absorption of other minerals, like excess selenium affects sulphur utilization. Therefore, the method of supplementing the most deficient minerals through area specific mineral mixture by analyzing the mineral status of soil, feed, fodders and animal of the region is most desirable strategy to overcome the mineral deficiencies in livestock.

Feeding of Total Mixed Ration or Complete Feed

The main principle of feeding total mixed ration is that all the ingredients (roughage and concentrate) are proportionally mixed and offered to the animal. The advantage of TMR feeding system is that uniform concentrate intake occurs for the day, than it is offered twice or thrice daily in the conventional feeding system. This enhances the digestibility of roughages, minimizes wastage, selectivity, reduces the nutrient loss and results in increased microbial protein synthesis and thereby improves the productivity and profitability. Concept of complete feeds allows incorporation of crop residues and unconventional feeds along with concentrate ingredients in a uniform mixture of mash or pellets by employing certain feed processing interventions like grinding, mixing and extruding. It makes rumen environment more stable with reduced energy loss, better ammonia utilization and stabilizes the acetate to propionate ratio. The utilization of low quality roughage can also be improved through complete feeds because of the readily available nitrogen and energy (Gowda et al, 2013).

Proper Monitoring of Dry Matter Intake

Monitoring of DMI is necessary to improve accuracy of ration formulation and animal performance. Proper ration formulation relies on many inputs from the farm, including animal body weight, feed inventory, and actual dry matter intakes. To decrease nutrient excretion per unit of milk produced, actual dry matter intakes must be known in order to ensure adequate grams of each nutrient are provided to support animal requirements. The data obtain can also be used as a diagnostic tool for forecasting various metabolic diseases.

Feed-Bunk Management

The objective is to increase intake and consistency of animal performance. This includes regular cleaning of mangers and pushing feed up several times daily etc. The consistent performance, and feed intake, allows for more accurate ration formulation for any production level.

Use of Diagnostic Techniques for Early Detection of Diseases

Use of metabolic profile test for non esterified fatty acids (NEFA), beta- hydroxy butyric acid, blood urea nitrogen (BUN), milk urea nitrogen (MUN) and creatinine serve as useful indicators for early diagnosis of diseases and to track the changes in ration formulation and feeding management.

Least Cost Ration Formulation

Recently apart from manual methods of ration formulation, software based program for ration computation are extensively being used by organized farms and feed manufacturers for forming low cost diet. It involves linear programming and software facilities. The basic information required is nutrient requirement, nutrient composition and cost of ingredients, its level of inclusions etc. These information and data is to be entered into the computer for ration computation.

Regular Assessment of Certain 'Indicators' To Track the Impact of Changes in Ration Formulation These 'indicators' fall into two categories: short-term (milk production, milk components, and milk urea nitrogen) and long-term (body condition score, replacement heifer growth, lactation persistency, and reproduction). Both sets of tools are required to accurately evaluate a herd.

Manure Analysis

Manure needs to be analyzed two ways: visual observation to determine what is not being digested by the cow, and the second is a manure nutrient analysis at time of land application. If large fiber particles or corn grain is evident in visual observation, rations and feeding management need to be addressed. As dietary N and P levels are decreased, manure nutrient concentrations will be decreased.

Conclusions

The concept of Precision feeding of the livestock is to enhance the production efficiency along with production of quality produces for the end users contributing to economical and cleaner environment. The use of strategies such as accurate ration formulation, reducing overfeeding of nutrients, strategic supplementation, use of feed additives and feed processing technologies will ensure the accomplishment of the objectives of precision feeding.

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