INNOVATIVE PROCESSES FOR ENHANCING MILK YIELD AND QUALITY

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The average yearly milk production for dairy cows and buffaloes in India is approximately 1000L; these production figures are about 1/10th of that observed in developed countries. The principal reason is the relatively low nutritive value eg, inadequate energy, a lack of metabolisable protein / essential amino acids and mineral deficiencies in the diet which is comprised primarily of crop residues and straw based constituents. An evaluation was undertaken of the strategic use and economic potential of using innovative feeding technologies including the role of by-pass proteins, slow release urea/protein complexes, mineral supplements and ration balancing programs. In this brief communication, the progress made on the utilisation of some of these feed technologies at the village level in India. This technology may also have application in other developing countries and may also assist in the major challenge facing the Pakistan dairy industry, to enhance milk yield of indigenous breeds of the dairy cow and buffalo will be summarised.
Keywords: Innovative processes, mild yield, milk quality

By-pass protein

In designing protein and/or amino acid supplements for lactating cows and buffaloes in India, it is essential to formulate supplements with an amino acid content that is complementary to microbial protein, which is considered to be the best available source of essential amino acids for milk synthesis. A detailed analysis of the nutritional characteristics eg, total protein, rumen undegradable protein (RUP, degree of natural protection), rumen degradable protein (RDP), essential amino acid profiles was undertaken on economically viable sources of protein enriched by-products e.g., oilseed meals/cakes.

There is considerable variation in the protein content and amino acid composition of the oilseed meals (Tables 1 and 2).

Table 1. Composition of by-product meals/cakes in India

Meal/Cake	%DM	% Protein	% Natural By-Pass
Soyabean meal	91	51	35
Tamarind seed powder	95	12	
Jowar grain	93	9	
Dhencha bhardo	95	39	62
Guar meal	93	54	27
Cottonseed cake	92	41	50
Sunflower meal	93	32	30
Groundnut cake	94	42	37
Rapeseed meal	93	42	41

A reliable procedure was developed which relied on a rumen ammonia release *in vitro* system with a good correlation with *in vivo* procedures (Gulati *et al.*, 2005). To optimise the by-pass content and bio-availability of the essential amino acids at the level of the small intestine, engineering design procedures were developed for the construction and operating of commercial plant(s) in India. Optimal treatment procedures were developed for each protein source; this provided a significant increase in the rumen undegradable protein (RUP) with a decrease in the rumen degradable protein (RDP).The bio-availability of the essential amino acids available for absorption at the small intestine were significantly enhanced by the treatment as compared to the untreated meals and cakes. By providing a complete protein source, the rate limiting amino acids required for enhancing milk yield were provided at adequate levels (Table 3).

A large number of feeding trials were carried out with by-pass (treated) protein meals in different regions of India. The results of these are summarised in Table 4; economic evaluations were undertaken to assess the impact of these feed supplements at the level of the village farmer (Garg *et al.* 2005; Monck and Pearce, 2008).

Minerals

Feeding mineral supplements has been demonstrated to assist the efficient utilisation of absorbed nutrients to improve growth, milk production and reproductive efficiency (McDowell, 1992). Over many years, NDDB has systematically mapped the macro and trace mineral profiles of different dairy regions of India, this information has enabled them to design area specific mineral supplements for lactating cows and buffaloes (Garg *et al.*, 2007c). This has resulted in a simple mineral mixture plant(s) which has been established in different regions across India. Many more need to be designed for specific minerals in different regions. Mineral mixtures are being incorporated into balanced rations for different regions.

Table 2. Amino acid composition of India protein sources (g/100g AA)

	Soya meal	Dhencha bhardo	Guar bhardo	Cotton cake	Sunflower meal	Groundnut cake	Rapeseed meal
Valine	2.37	1.22	1.75	1.66	1.42	1.5	2.19
Cystine*	0.79	0.49	1.23	0.77	0.74	0.58	1.22
Methionine*	0.67	0.22	0.47	0.56	0.53	0.33	0.71
Isoleucine	2.69	1.37	1.46	1.2	1.34	1.77	1.81
Leucine	4.38	2.31	2.58	2.07	2.04	2.58	3.81
Phenylalanine	2.57	1.33	1.86	1.96	1.26	1.75	1.73
Lysine	3.51	1.82	2.17	1.7	1.15	1.45	2.57
Histidine	1.23	0.79	1.25	1.01	0.68	0.79	1.26
Arginine	3.64	3.01	6.39	4.15	2.36	3.96	2.66

Table 3. Bio-availability of amino acids in protein meals

EAA available for absorption	Sunflower meal		Rapeseed meal		Guar bhardo meal		Groundnut cake	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
Cysteine	0.73	1.84	1.95	3.71	1.73	4.98	0.90	1.83
Methionine	0.52	1.31	1.14	2.17	0.66	1.90	0.51	1.04
Isoleucine	1.33	3.32	2.90	5.50	2.05	5.91	2.75	5.58
Leucine	0.02	5.06	6.10	11.58	3.62	10.45	4.01	8.13
Phenylalanine	1.25	3.12	2.76	5.25	2.61	7.53	2.72	5.51
Lysine	1.14	2.85	4.12	7.82	3.05	8.79	2.25	4.57
Histidine	0.67	1.69	2.01	3.82	1.76	5.06	1.23	2.49
Arginine	2.34	5.85	4.26	8.09	8.97	25.88	6.15	12.47

EAA-Essential amino acids

Table 4. Economic evaluation of feeding by-pass (treated) protein meals

	Sunflower meal		Rapeseed meal		Guar bhardo	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Milk response (L)	8.4	9.5	8.5	9.6	7.8	8.5
Economic value						
Net gain per cow/d (Rs)		9.61		9.44		9.3
Net gain per buffalo/d (Rs)		14.99		12.41		8.6

Source: Garg *et al.* (2003; 2005); Monck and Pearce (2008)

Table 5. Examples of designing the fatty acid composition of milk

Fatty Acid	Common Name	Pasture	Breast	Designed Infant formulations			
			Australia	#1	#2	#3	#4
C12:0	Lauric	3.43	5.51	2.35	2.13	3.56	2.17
C14:0	Myristic	11.97	6.28	8.24	8.64	12.10	7.46
C16:0	Palmitic	28.50	22.26	22.88	23.10	26.09	17.53
C18:0	Stearic	9.32	6.77	12.40	11.45	6.14	12.88
C18:1	Oleic	30.86	34.95	31.81	30.71	24.01	39.27
C18:2n6	Linoleic (LA)	1.87	10.66	6.10	9.63	7.07	8.81
C18:3n3	Linolenic (ALA)	0.73	0.17	1.28	1.76	1.11	3.32
C20:4n6	Arachdonic (ARA)	0.08	0.38	0.13	0.05	0.65	0.09
C20:5n3	Eicosapentaenoic (EPA)	0.08	0.10	0.39	0.72	0.77	0.11
C22:5n3	Docosapentaenoic (DPA)	0.11	0.18	0.46	0.46	0.34	0.01
C22:6n3	Docosahexaenoic (DHA)	0.01	0.23	0.38	0.38	0.95	0.00
	ω-6	1.95	11.04	6.23	9.68	7.72	8.90
	ω-3	0.93	0.68	2.51	3.32	3.17	3.44
	Saturated	53.22	40.82	45.87	45.32	47.89	40.04
	Unsaturated	33.74	46.67	40.55	43.71	34.90	51.61
	Ratio Sat:Unsat	1.58	0.87	1.13	1.04	1.37	0.78

Recent challenges

In the new millennium, the challenge is to design feed supplements in a cost effective way to produce nutritionally enhanced milk and dairy products to benefit the dairy industry and consumers. An example of this is to design infant/toddler milk with enhanced levels of n-3 fatty acids that are very important in neural development, vision and cognitive behaviour in children. Preliminary studies indicate that by designing feed supplements, it is possible to create a composition in cow's milk that is similar to that in human breast milk (Table 5; Gulati *et al.*, unpublished data).

The application and role of rumen protected nutrient feed supplements for enhancing productivity in the dairy industry needs to take into account some of the following parameters:

1. The type and quantity of rumen protected protein (RP protein) supplements that are required for different outcomes and various species?
2. The type and quantity of rumen protected fat (RP fat) supplements required for different outcomes and various species?
3. What is the optimal feeding strategy and how is this influenced by genotype, stage of lactation and environmental stress?
4. Goals to be achieved from using RP fat & RP protein feed supplements

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