Animal Feed Biotechnology and Industry in Asia-Pacific Region

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Abstract

As a consequence of the world's population increases, the food demand is necessarily required for human consumption particularly protein sources from egg, meat and milk. Improvements and efficiency in producing these products through improved nutrition and feeding have been reported by the uses of biotechnology and industry which include areas of feed processing, feed additives, immune modulation, enzyme biocatalyst, rumen enhancers, growth hormones etc. Examples of feed biotechnology and industry in non-ruminants have been emphasized on the uses of feed additives, enzyme biocatalyst while in ruminants are the uses of feed processing, rumen enhancers (feed additives *I* ionophores *I* antibiotics *I* probiotics), rumen manipulation and growth hormone (bovine somatrotopin, BST) etc. Significant improvements have been obtained in feed quality, intake, digestibility especially rumen ecology and subsequent growth and milk productivity. It is, however of paramount importance in the Asia-Pacific region to consider the optimal use of locally available feed resources such as cassava as energy and cottonseed meal as protein or other protein by-products or rice straw based diets for ruminants, the ~nimal nutritional status and the economical justification to best suited with the use of prevailing biotechnology and industry in order to maintain and improve animal's health and welfare, management and productivity as well as to enhance human dietary consumption and safety.

INTRODUCTION

Livestock production in the Asia-Pacific region involves subsistence, semi-intensive and intensive or industrial production systems (Wanapat, 1995). The changing of production systems according to resource use, management and scale is quite"dynamics. Chantalakhana (1990) presented in great details relating to farming systems characteristics and their structures. Non-ruminant production both swine and poultry depend mainly on cereal grain (corn) and protein source (soybean) whilst ruminant production of buffalo, beef and dairy cattle, sheep and goats have ability to utilize fibrous feeds and crop-residues and strategic supplements. However, production efficiency needs to be enhanced to meet up with great demand of animal protein sources, for increasing world population especially in the Asia-Pacific region. Biotechnology has been shown to have impact on animal nutrition and feeding, animal production and feed industry as will be addressed hereafter.

Feed Processing, Technology and Industry

The overall objectives of feed processing are mainly to reduce feed particle size, increase density, increase feed homogeneity, enhance feeding value, palatability, acceptability and overall intake by animals, in addition it also increases efficiency of storage, transportation and handling both at short and long terms. Feed processing and technology for non-ruminant complete feeds have been successfully practiced using grinding and pelleting. In addition, the heat involved in pelleting is believed to be contributing to inactivate heat-labile toxins as well as improve nutrient utilization such as amino acids and phosphorus. For ruminants, although numerous methods have been employed in developed countries to process energy sources namely grinding, extruding, pelleting (dry processing), steam rolling, steam flaked, pelleting with steam, exploding (wet processing), it is not yet the case in the Asia-Pacific region since different type of energy sources as well as economical justification have not been elucidated. Roughages and fibrous feeds particularly crop-residues for ruminants have been receiving greater attention for research and development in finding the most appropriate and practical methods including physical, chemical, physio-chemical and biological methods (Doyle et al., 1985; Wanapat, 1994, 1995a; Devendra, 1992). Among various methods, urea-treatment using 5 kg urea, 100 kg water and poured on 100 kg straw has been most efficient in improving straw nutritive value and well-accepted by farmers.(Wanapat, 1990; Hart and Wanapat, 1992) (Table 1). Nevertheless, larger scale preparation and probably at industrial level warrants immediate undertaking in order to extend the use for longer period and reduce frequency and labour involved. With seasonal availability and wide distribution of these roughages and crop-residues, process to collect and store in efficient way be essentially required. Simple pelleting of fibrous feeds e.g grass hay, rice straw, corn stover, sugar-cane top could be successfully prepared using dietary binders (Wanapat, 1996, unpublished data). Current interest and attention has been shown on the use of total mixed ration (TMR) in high productive livestock like finishing cattle and dairy cattle in order to gain benefit of balanced ration, maintaining continuous intake, establishing optimal rumen fermentation, thus resulting in useful end-products for productive purposes. Maltz et al. (1992) reported in details on comparative use of TMR and individual concentrate feeding. In Asia-Pacific region, farmers with limited resources have shown interest and potential in using TMR if proved to be efficient and economical. However, type of fiber and processing method of TMR are considered to be essential elements in achieving good quality TMR. Rice straw has been shown to be successfully incorporated in TMR as an effective fiber source in dairy ration. Another challenging area is to develop new feed product to improve the use of energy source especially cassava and non-protein nitrogen like urea, a product called "Cassarea" (Wanapat, 1996, unpublished data) to be used in beef and dairy rations. Industrial use of this product in complete ration deserves immediate undertaking.

Table 1. Effect of urea-treatment (5% w/w) on intake and digestibility of rice straw.

	Untreated Straw+Urea	Urea-treated Straw
VFI, kg/d	3.06^{a}	3.82^{b}
Digestibility,%		
DM	55^{c}	65^{b}
OM	60^{c}	70^{d}
NDF	60^{a}	72^{b}
ADF	56^{a}	66^{b}
Mineral absorption,%	41^{c}	46^{d}
Rum Cr-mordanted fiber,h	85^{a}	58^{b}
pH	6.5	6.5
NH_3-N,mg%	18.3^{a}	9.8^{b}
VFA,m mole/l	61.1^{a}	81.8^{b}

a, b <0.01 c,d $P<.05$ Hart and Wanapat (1992)

Uses of feed additives/ionophores/antibiotics/probiotics/growth hormone

The impact of biotechnology on animal nutrition has been significant as shown on various currently organized conferences on animal production (Hunter, 1989; Forsberg et al., 1993; Headon, 1993; Rowlinson 1993; Lyons and Jacques, 1994). Lyons (1994) comprehensively summarized the potential areas of biotechnology which include in non-ruminants, the uses of enzymes (α-amylase, phytase), feed additives /antibiotics to increase feed efficiency, growth rate and / or to reduce mortality rate. Simons et al. (1990) reported an increase of P availability from 52 to 62% when phytase was added to chicken diet where growth rate was significantly improved and P in feces decreased by 50%. In ruminants, recent literatures have shown remarkable findings in using ionophores (e.g. monensin or rumensin) in improving rumen ecology by means of stimulating the growth of gram negative bacteria while inhibiting those of gram positive bacteria through their differences of having more complex outer membrane, respectively in which Na+ and K+ pump between extracellular and intracullalar, osmotic equilibrium and pH of cells were remarkably interfered (Russell and Strobel, 1989). Table 2 shows rumen bacteria and their activity and fermentation products to rumensian. Mode of action is illustrated in Figure 1 (Russell and Strobel 1989). A number of detailed literatures have been reported on the beneficial uses of ionophores, antibiotics and probiotics including those of Dawson (1993), Wallace and Newbold (1993), Wallace (1994). The mode of action in rumen especially of probiotics (yeast) is illustrated in Figures 1 and 2.

Enhancement of crude protein content up to 60% of energy-based feed e.g. cassava, corn or molasses can be manipulated to obtain single cell protein (SCP) through bacterial, fungal or photosynthetic algae microorganisms.

Some literatures on the uses some of probiotics and ionophores are presented in Table 3. Despite the improvements obtained, it is considered essential to verify and implement the use in the Asia-Pacific region to match with existing feeding systems especially high fibrous and crop-residues available as well as the economic justifications and perceptions.

Table 2. Fermentation products of rumen bacteria and their sensitivity to rumensin.

Rumensin Sensitive:	Fermentation Products	Rumensin Insensitive:	Fermentation Products
Ruminococcus	Acetate	Selenomonas	Propionate
Methanobacterium	Acetate, Methane	Bacteroides	Acetate, Propionate
Lactobacillus	Lactate (Acidosis)	Megasphera	Propionate, Acetate
Butyrivibrio	Acetate, Butyrate	Veillonella	Propionate
Lachnospira	Acetate	Succinimonas	Succinate
Streptococcus	Lactate (acidosis, bloat)	Succinivibrio	Succinate
Methanosarcina	Methane		
Fibrobacter	Acetate		

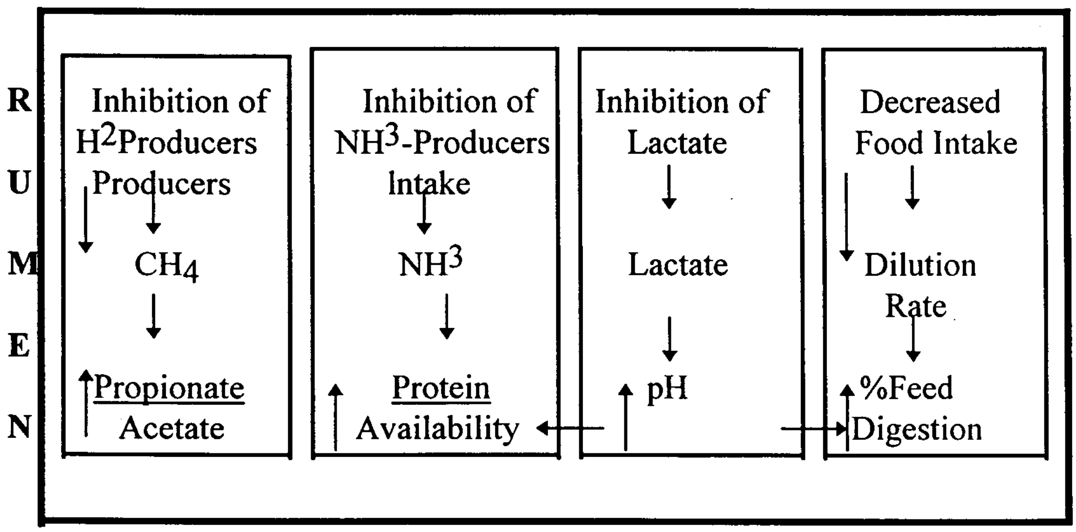

Fig. 1. Summary of possible effects of monensin on ruminal fermentation (Modified from Russell and Strobel, 1989)

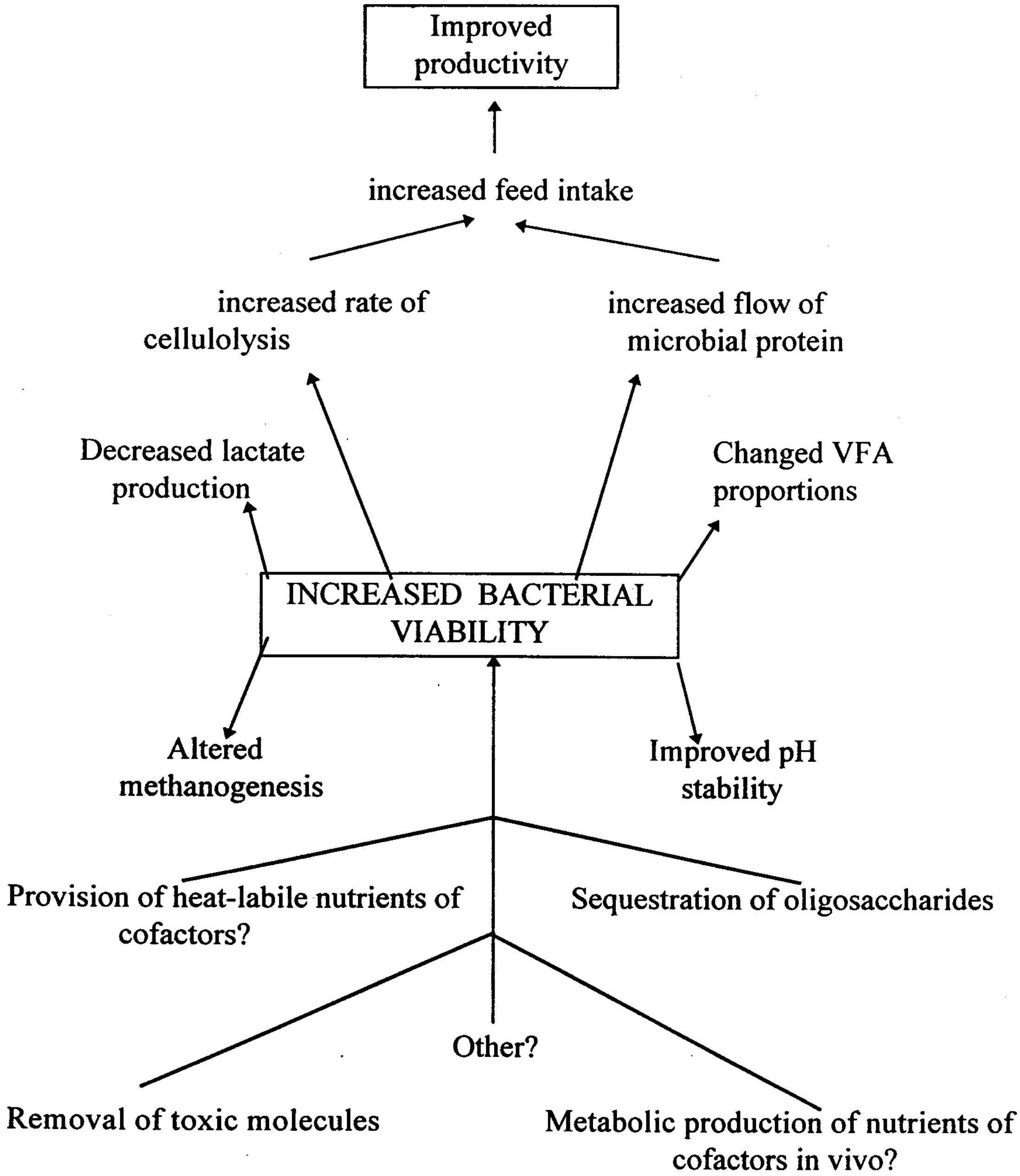

Fig. 2. A model for the mode of action of yeast culture Wallace and Newbold (1993).

Table 3. Effects of probiotics, yeast *(Saccharomyces cerevisiae)* and/or fungal culture *(Aspergillus oryzae)* and ionophores in ruminant species.

Probiotics/Ionophores	Species	Performance	Reference
Saccharomyces cerevisiae	Dairy	increased intake. ADG, milk yield	Gomez-Alarcon et al. (1990)
Saccharomyces cerevisiae	Dairy	increased rumen fermentation	Carro et al. (1992)
Saccharomyces cerevisiae	Beef	increased rumen fermentation	Caton et al. (1993)
Saccharomyces cerevisiae	Swamp Buffalo/Beef	increased intake	Wanapat et al. (1991)
Saccharomyces cerevisiae	Beef/Dairy/Swamp Buffalo	increased rumen fermentation	Sommart and Wanapat (1992)
Saccharomyces cerevisiae	Dairy	increased rumen fermentation intake, milk yield	Piva et al.(1993)
Saccharomyces cerevisiae	Murrah buffalo	increased milk yield and compositions	Sengupta and Kar (1994)
Saccharomyces cerevisiae	Dairy	no improvements	Swart et al.(1994)
Aspergillus oryzae	Dairy	increased intake. milk yield	Gomez-Alarcon et al. (1991)
Aspergillus oryzae	Dairy	no improvements	Varel and Kreikemeier(1994)
Aspergillus oryzae	Dairy	increased rumen fermentation	Yoon and Stern (1996)
Monensin	Feedlot cattle	increased rumen fermentation, energy utilization	Richardson et al. (1976)
Monensin	Beef/Dairy Cattle	Antiketogenic effect, Acidosis prevention, milk yield	Saur et al.(1989), Nagaraja et al. (1981), Elanco (1995)
Monensin	Feedlot cattle	increased feed efficiency	Goodrich et al. (1984), Richardson (1990)
Monensin/tylosin		decreased intake, increased ADG and feed efficiency	Stock et al. (1990, 1995)
Lasalocid	Dairy cows	increased rumen fermentation, milk protein, decreased BW loss	Knowlton et al.(1996), Knowlton et al.(1996a), Dye et al. (1988)
Virginiamycin		Feedlot cattle increased growth, feed efficiency	Hedde et al(1980), Rogers et al.(1995)
Loidlomycin propionate	Feedlot cattle	increased feed efficienc, and gain, rumen fermentation	Spires et al.(1990), Spires and Algeo (1983)

Manipulation of ruminal fermentation has been shown as a major step in improving ruminal degradation, fermentation and increasing overall feed utilization (Nolan and Leng,1989; Orskov and Flint, 1989; Mason et al.,1989). Defaunation in the rumen was shown to be beneficial to increase rumen efficiency (Jouany et al., 1988; Ushida et al., 1991). Besides the uses of above compounds, developments in recombinant DNA technology in ruminal microbiology have been receiving much attention especially developing genetically modified bacteria with enhanced fibrolytic activity into the reticulo rumen (Armstrong and Gilbert, 1991; & Gilbert and Hazlewood, 1991; Forsberg et al ; 1993) and to degrade toxic compounds and antinutritional factors widely distributed among tropical feeds e.g. mimosine in *Leucaena*, cyanide in cassava and gossypol in cottonseed (Orskov and Flint, 1989), and introduction of genes for escape protein e.g. cycteins and production of biological control agents to protect host from parasites or to reduce selected microorganism populations within rumen (Gregg and Sharpe, 1991). These genes can also be introduced into non-ruminants to enhance their capacity to digest complex carbohydrate (Forsberg et al., 1993). Wallace (1994) addressed that if genetically engineered ruminal microorganisms to be used for nutritional purposes, three scientific objectives must be met : 1) to insert new genetic material into ruminal species and ensure that it is expressed, 2) to select a gene product or products that will benefit nutrition of the host and, 3) to establish a means by which the new organism can survive. Improvement of silage preservation by increased fiber degradation to produce optimal lactic acid by addition of enzymes cellulases, hemicellulases, pectinases and amylases (McDonald et al., 1991). Genetically modified *Lactobacillus* strains have been developed which express endoglucanases and xylanases from genes cloned with *Clostridium thermocellum, B. fibrisolvens and C. acetobutylicum* (Scheirlinck et al. 1990). Although recombinant DNA technology or genetic engineering has given a major impetus and revealed challenging new findings as well as problems to ruminal biotechnology, a lot still remains to be done which will lead to a new era in animal nutrition and feeding practices.

Bovine somatrotopin (BST) is naturally occurring growth hormone from pituitary which biologically effects on growth and lactation (Peel and Bauman, 1987). Administrations of recombinantly derived bovine somatrotopin have been shown to significantly increase milk yield and feed intake in dairy cattle raised in temperate (Phipps et al., 1990; Myung, 1990) and in the tropics of *Bos indicus*, dairy crossbred and *Bos taurus* cows (Phipps et al. 1991). Chalupa et al.(1996) presented comprehensive details on the use of BST (10.3, 20.6,41.2 mg/d) during weeks 5 to 43 of lactation and it was found that cows produced more milk, consumed more feed, has lower rates of BW gain and improved efficiencies of milk production. Higher dose of BST (4.1 mg/d) had reduced fertility but was not affected by lower doses (10.3, 20.6 mg/d). The increases in milk yield of dairy cows treated with BST are believed to be the result of coordinated metabolic adaptations in various tissues especially adipose tissue in response to energy balance of the cows (Bauman and Vernon, 1993; Lanna et al., 1995). The health of treated dairy cows in terms of body temperature, heart and respiration rates were unaffected by the administration of BST (Weller et al., 1990). It appeared, however that dairy cows receiving BST were in good condition and fed high plane of nutrition thus cows producing lower level of milk and are fed with high fibrous feeds or crop-residues should be further investigated for responses.

CONCLUSIONS AND RECOMMENDATIONS

Since feed resources and their efficient utilization are considered first limiting factor to improve animal productivity, animal and biotechnology and industry in the Asia-Pacific region will certainly play a significant role and has a great impact on improving and increasing animal productively

Feed resources with regards to availability and quality as well as their convenient physical forms for use are quite essential for storage and distribution. Potential technology in regards to physical and chemical processing as well as TMR and new product like "Cassarea" for feed industry have been generated and deserve further undertakings for application. Although interesting and promising findings for animal feed biotechnology have been found, a lot remain to be researched especially the uses of recombinant DNA technology for sustainable processes and products as well as the health and welfare of the animals and the consumer's concern.

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