Objectives of the feed manufacturers conference from a scientific point of view

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Objectives of the feed manufacturers conference from a scientific point of view

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SUMMARY - This conference plays an important role in assisting feed industry, in maintaining itself efficient, as an up-to-date and forward looking. The aim of this conference is to provide information which can readily be applied to commercial situation and stimulate discussion among delegates. The presentation has been in focus on four examples of scientific relevance: protein requirements of ruminant livestock, relationship between trace nutrients, use of enzymes in feed industry and biotechnology in feed industry.

Key words: Biotechnology, feed industry, scientific relevance.

RESUME *- "Objectifs de la conférence des fabricants d'aliments du point de vue scientifique". Cette conférence joue un rôle important en apportant son assistance à l'industrie des aliments pour bétail, pour maintenir son efficacité, l'actualiser dans ce domaine et l'orienter vers le futur. Le but de cette conférence est de fournir une information qui soit d'emblée applicable à la situation commerciale et qui stimule la discussion parmi ses représentants. La présentation est axée sur quatre exemples d'importance scientifique : les besoins protéiques des ruminants, le rapport entre les oligoéléments, l'utilisation d'enzymes et la biotechnologie dans l'industrie des aliments pour bétail.*

Mots-clés : *Biotechnologie, industrie des aliments pour bétail, importance scientifique.*

Introduction

It is a pleasure to contribute to the Proceedings of this South European Feed Manufacturer's Conference. The author holds firmly to the belief, based upon experience in the USA and the UK that such conference, held on a regular basis play an important role in assisting the feed industry in maintaining itself as an up-to-date, efficient and forward looking industry.

Most of those present today will be aware that such conferences have been, and are being held on an annual basis at a number of university centres in the USA. Since January 1967 the University of Nottingham in the UK annually hold a feed manufacturers conference along similar lines to those in the USA. At these American and British conferences the topics included for discussion relate to ones of particular interest or concern at that time. It is noteworthy that the annual Nottingham University conference is regularly attended by some 400-500 delegates and attendance at it is a first priority for many feed industry personnel in the UK and continental Europe.

Among important objectives of the present conference, as referred to by the first speaker, is the provision of a forum in which recent knowledge relevant to the industry can be disseminated and discussed, problems related to the industry can be pin-pointed and, where possible guidance given on overcoming them.

From a scientific view point there are a number of objectives. One such is to focus attention on the importance of new scientific knowledge with reference to the nutrient requirements of livestock including horses, fish and household pets, and how these may be met by modifications to feed formulation. Other objectives are focusing attention on changes in animal husbandry practice, on new and more effective methods for the analysis of feeds and forages for feed evaluation, and on developments in engineering processes involved in feed processing. Further important scientific objectives include examination of relevant economic data and discussions relating to current feedstuff legislation. These last two aspects will be dealt with by Dr. Brian Cooke in the next paper.

It is intended that the conference papers will provide information that can readily be applied to the commercial situation and stimulate discussion among delegates. Every attempt should be made to ensuring that the conventional restrictions on scientific communication - viz opinions being expressed only with an obligatory requirement for published supportive evidence - does not impede a reasoned presentation of practical issues in the topics chosen.

For the purpose of this presentation attention has been focused on four examples of scientific relevance to ensuring an efficient feed manufacturing industry. The first refers to the important consideration of protein requirements of ruminant livestock; protein and energy supply in the feed are of prime concern in successful feed utilisation. The second refers to the interrelationships between nutrients with reference to selenium and vitamin E. The third example refers briefly to enzyme supplementation of pig and poultry feeds while the final example relates to some developments arising from the application of biotechnology to the feed industry.

Protein requirements of ruminant livestock

Protein requirements of ruminant livestock are a very important aspect of feed formulation. It is a field that has received a very considerable amount of scientific attention these past 10-15 years and about which there is still a great deal to learn. Central to this field of study is the fact that early intervention of microbial fermentation of the feed supply in the digestive tract ensures that a major part of the animal's essential amino acid supply arises from microbial protein synthesised within the reticulo-rumen and subsequently digested by host-enzyme digestion in the true stomach and small intestine. The other source of amino-acid supply is the release of amino acids, also in the true stomach and small intestine, from host enzyme digestion of rumen-unfermented feed protein (the so called undegraded or by-pass protein). Thus difficulties arise not only in determining amino acid (protein) requirements but in assessing the extent to which specific dietary feed formulation meets these requirements. This uncertainty is reflected firstly in the fact that while there is general acceptance of the above outline, different countries use different factors for assessing requirements and particularly in determining the extent to which feeds supply these requirements.

Thus in the United Kingdom, the Metabolisable Protein (MP) system has recently been proposed (AFRC, 1992, 1993) in which protein requirements and the capacity of feeds to meet these requirements are measured in units of metabolisable protein. In France, Italy and Spain protein evaluation is based on the determination of protein digestion in the intestine (PDI), (INRA, 1978, 1988; Cano, 1995). In Switzerland a simplification of the French INRA system is used (Landis, 1979) while in the Netherlands the DVE (digestible protein in the intestines) system is used (Tamminga *et al.*, 1994). In the United States of America the system used is based upon absorbed protein (NRC, 1985) although the factors used in determining the absorbed protein values of feeds or feed combinations differ from one US State to another. The Scandinavian countries (Denmark, Finland, Iceland, Norway and Sweden) have, since 1986, used the Nordic AAT - PBV system (Madsen, 1985). [AAT-amino acids absorbed in the intestine and PBV-protein balance in the rumen]. While in all systems there is general acceptance that the ruminant's supply of essential amino acids (and non essential amino acids) is made up of microbial protein and unfermented feed protein, both undergoing proteolysis in the true stomach and small intestine, the factors used in deriving these quantities for a specific animal or in a specific feeds, differ one country from another.

Furthermore in the United Kingdom the picture is further complicated by the fact that in attempting to incorporate the latest acquired knowledge of ruminant protein (N) digestion, major changes in the newly proposed system have taken place at what is, for scientific matters, at relatively short intervals of time. The digestible crude protein system (ARC, 1965) was discarded by the Agricultural Research Council's Committee on Nutrient Requirements (ARC, 1980, 1984) in favour of a model consistent with the most recent knowledge of ruminant protein digestion. Recently this approach has been further refined and extended as the Metabolisable Protein system; it is detailed in the AFRC, TCORN Report No 9 (1992) entitled Nutrient Requirements of Ruminant Livestock: Protein. Recently, an advisory manual written by Drs G. Alderman and B.R. Cotterill and published under the title Energy and Protein Requirements of Ruminant (AFRC, 1993) has been published. It is to be noted that in this last-mentioned manual the tables of protein (and energy) requirements have all been increased by 5% as a safety margin. Clearly it is of importance for those concerned in feed formulation to keep abreast of these developments in protein digestion and metabolism.

Interrelationships between trace nutrients

An example of an interrelationship between micro nutrients with relevance to animal well-being is seen with selenium (Se) and vitamin E, Nutritional muscular dystrophy (NMB) and 'stiff-lamb' disease in lambs are the two most well known examples of vitamin E/Se deficiency in ruminants; Mulberry Heart Disease in pigs and Exudative Diathesis in chicks are examples in simple-stomach animals.

The following is a brief outline of the role of these two interrelated micro nutrients. A free radical is a molecule containing a single, unpaired electron. Although controlled free-radical production is a necessary occurrence in cell function, it is important to prevent excessive free-radical formation. Free-radicals capable of oxidation can remove a H from a polyunsaturated fatty acid (PUFA) molecule thus initiating lipid peroxidation:

LH - H → L•
(lipid)

L• + 0_2 → L00•
(lipid peroxide, free-radical)

L00• + LH → L00H + L•
(lipid) (lipid hydroperoxide)

The above series of reactions is self perpetuating and, in the absence of vitamin E results in the conversion of the lipid into hydroperoxides which are further metabolised in the cell giving rise to toxic metabolites. Vitamin E, as a lipid-soluble antioxidant acts as a scavenger of free-radicals in the lipid environment of cell membranes, thereby preventing the formation of the lipid peroxides. Vitamin E exerts its antioxidant effect through the -OH on its phenol ring; this donates a H to the lipid peroxide free-radical thereby quenching the chain reaction. The tocopherol free-radical thus formed is removed continuously by reaction with vitamin C.

L00•	α tocopherol -OH	Vitamin C•
L00H	α locopherol -O•	Vitamin C

In a separate reaction vitamin E also facilitates the conversion of the lipid peroxide (L00H) to the lipid alcohol LOH which is not toxic. However the vitamin E involved in this reaction cannot be regenerated and is excreted from the body.

In an independent reaction the enzyme glutathione peroxidase, of which Se is an essential component, converts peroxides, including L00H, to their corresponding alcohols. This reaction provides a second mechanism for removing potentially toxic lipid peroxides from the cell and accounts for the known interrelationships between vitamin E and Se in livestock nutrition. It should be noted (ARC, 1980) that metabolic disorders in livestock only responsive to treatment with Se occur and others only responsive to Vitamin E therapy exist, these last-mentioned usually associated with high levels of intake of PUFA. However it is clear that where Vit E/Se are both involved in the manifestation of deficiency symptoms it is important to recognise the interrelationship between the two micro-nutrients. Recognising one as deficient without consideration of the other could be a very unwise course of treatment.

Use of enzymes in the feed industry

Until quite recently enzymes have found only limited practical use in the feed industry because of their relatively high cost in relation to the benefits arising from their use. However with the advances in biotechnology, production costs of certain enzymes has been considerably reduced with the result that commercial use of enzymes in the animal feed industry is becoming established practice.

As mentioned in the introduction to this paper, one of the purposes of such conferences is to ensure that attention is drawn to new developments, that delegates are provided with knowledge of the science on which such developments are based and have the opportunity to discuss the more practical aspects necessary for the successful incorporation of the practice into the feed industry. Economic considerations must be taken into account in deciding whether a new development is justified in being used. Since the subject of enzymes is being dealt with in a later session only brief reference will be made to the subject here.

Essentially enzymes have two roles to play in the feed industry. The first, of relevance to poultry and pigs relates to the addition of enzymes to the feed prior to its ingestion by the animal. The second role relates to the use of enzymes as silage additives whose purpose is to enhance efficiency of fermentation and hence nutritive value of the conserved feed; in certain cases the additive is an enzyme complex of cellulases and xylanases, in others the additive is a bacterial culture which yields enzymes as it multiplies. No further reference will be made to this second role.

(i) The addition of carbohydrase enzymes to poultry and pig feeds: The nutritive value of cereals such as barley, oats, triticale and rye for the young bird is adversely affected by the presence in the grains of appreciable amounts of non-starch polysaccharides (NSP) such as β-D-glucans and/or pentosans such as arabinose-xylan polymers. A high proportion of these components of the endosperm cell wall are water-soluble, and when ingested in the feed give rise to viscous gels. The resulting marked increased in viscosity of the intestinal digesta has certain adverse physiological effects. Action of the digestive enzymes is impaired, there is decreased digesta flow and absorption of the end products of digestion from the intestine, feed intake is reduced and there is the production of sticky droppings. The addition of carbohydrase enzymes (β glucanase and xylanase) assists in degrading these NSP thereby markedly reducing the viscosity of the digesta.

- Graham and Petterson (1992) have reported the results of a study in which broiler chicks were fed for 21 days on barley-based diets alone or when supplemented with either a β glucanase enzyme product from *Tricholderma longibranchiatum* (Finn Feeds International Ltd) added at a level of $300U.kg^{-1}$ or a multi-enzyme product (Avizyme SX; Finn Feeds Ltd). This last mentioned product was used at a level to give the same β glucanase unit activity as the first enzyme product but also provided $300U.kg^{-1}$ of xylanase (from *T. longibranchiatum*) and $15\ U.kg^{-1}$ cellobiase (from Aspergillus niger). The feed was fed as mash and the results are shown in Table 1. It can be calculated from the data that the addition of the β glucanase alone increased liveweight gain by 64% and feed conversion efficiency by 19%; the use of the multienzyme product gave improvements of 80% and 20% for these parameters.

Table 1. Production data relating to chicks fed a barley-based mash alone or when supplemented with a β glucanase enzyme or with a multienzyme product (data of Graham and Pettersson, 1992)[†]

	Control	+ β glucanase	+ Multi enzyme complex
Liveweight at 21 days	352^a	578^b	634^b
Feed intake (g)	627^a	878^b	958^b
Feed conv. efficiency	2.05^a	1.66^a	1.63^b
Frequency (%) of sticky droppings at day 7	23^a	11^b	4^b

[†]Means in same row not sharing same superscript significantly different $P<0.05$

(ii) The addition of phytase to poultry and pigs feeds: Phytate is the storage form of phosphorous (P) which occurs in all plants and is a potent chelator of minerals. Phytase is an enzyme which hydrolyses phytates to organic inositol and P and in the process liberates chelate-bound minerals. The data shown in Table 2 are those of Broz and Perrin-Voltz, 1991, with broiler chicks fed a maize/soyabean meal with no added inorganic P. From Table 2 it can be seen that the presence of the phytase enzyme increased weight gains and the apparent availability of P. The last mentioned result was associated with a decline in the P concentration of the excreta (g.kg $^{-1}$ dry matter) from 6.92% in the control to 6.32% (enzyme as powder) and 6.22% (enzyme as liquid).

Table 2. Effects of supplementing a low P diet fed to broiler chickens with a fungal phytase at 500 phytase units, kg^{-1} (Broz and Perrin-Voltz, 1991)[†]

	Control	Phytase (powder)	Phytase (liquid)
Performance (day 8-22)			
Mean weight gain (g)	357.6^{c}	380.8^{b}	404.4^{a}
Mean feed intake (g)	658.3^{b}	680.3^{b}	718.9^{a}
Feed conv. effic.	1.84	1.79	1.78
Apparent avail. of P (%)	44.32^{b}	52.32^{a}	52.71^{a}

[†]Means in rows carrying different superscripts significantly different P<0.05

- Simons *et al.* (1990) studied the effectiveness of their phytase enzyme product in pig feeds. The enzyme was added at 1000 units kg^{-1} feed. Apparent digestibility of P was again increased as can be seen from the results shown in Table 3. The data shown in Table 4 are those of Jongbloed *et al.* (1993) showing the performance of piglets from 11-25 kg liveweight and fed a basal diet with either an inorganic P supplement (1.0 and 2.0 g P.kg^{-1} feed) or a microbial phytase (1500 phytase units (PTU).kg^{-1} feed). The piglets receiving the phytase-supplemented feed showed a 25% higher body weight gain than the control animals associated with a 15% increase in mean daily feed intake. Compared with the animals receiving supplementary P(2 g.kg^{-1} feed), those receiving the enzyme gained 16% more weight and ate 9% more feed.
- It is clear from the foregoing results that supplementation of pig and poultry diets with an active phytase preparation would reduce usage of additional P in such feeds or remove the necessity of supplemental P entirely. There is the additional benefit of reducing pollution of the environment with high P-containing excreta. There is much yet to learn before enzymes such as the phytases are in widespread production. The question of the best means of incorporating such enzymes into feed mixes, under practical conditions must be established for it must be emphasised that the core structure of enzymes are amino acids linked as peptide chains and are very vulnerable to irrevocable heat damage.

Table 3. Apparent availability's of P and Ca in a high-maize diet fed to pigs (46-60 kg) in the absence or presence of microbial phytase (Simons *et al.*, 1990)

	Microbial phytase		Significance
	-	+ve	
Digestibility of dry matter	0.852	0.850	NS
Apparent availability of P	0.2	0.46	**
Apparent availability of Ca	0.44	0.50	NS
P in faeces (g.kg^{-1}DM)	21.0	13.6	**
Ca in faeces (g.kg^{-1}DM)	22.8	19.2	*

NS: Non significant; *P<0.05; **P<0.01

Biotechnology and the feed industry

There is little doubt that as we move into the 21 st century developments arising from the application of biotechnology will prove of increasing importance to the feed manufacturing industry. There are many definitions of biotechnology; one such used by the European Federation of Biotechnology defines it as "The integrated use of biochemistry, microbiology and chemical engineering to achieve industrial applications of microbes and cultured tissue cells".

Table 4. Performance of piglets from 11-25 kg bodyweight fed a basal diet with either supplementary inorganic P 1.0 - 2.0 g.kg^{-1}) or microbial phytase (1500 phytase units [PTU].kg^{-1}) Jongbloed *et al.* (1993)[†]

Treatment	n	Bodyweight (kg)		Daily gain (g/day)	Feed intake (g/day)	FCR (gain/feed)
		start	end			
Basal diet (BD)	93	11.2	23.5^{a}	424^{a}	695^{a}	1.65^{a}
BD + 1.0 g P/kg	95	11.2	24.7^{b}	460^{b}	739^{b}	1.59^{b}
BD + 2.0 g P/kg	95	11.2	24.4^{ab}	456^{b}	735^{b}	1.62^{ab}
BD + 1500 PTU/kg	93	11.2	26.5^{c}	529^{c}	802^{c}	1.52^{c}

[†]Means in rows carrying different superscripts significantly different $P<0.05$

With reference to the feed industry, areas of particular interest can be listed as:

- Improvement in the nutritive value of feedstuffs.
- Improvement in the digestive capability of farm livestock.
- Changes in mammalian metabolism.
- Introduction of novel feed sources.

(i) Improvement in the nutritive value of feeds: In Europe, barley and to a lesser extent wheat are the major components of pig diets supplying most of the energy and some 55-70% of the daily protein requirements. The poor nutritional value of barley grain is largely determined by the low levels of lysine (first limiting amino acid) threonine (second limiting) and to a lesser extent histidine (third limiting) in the protein relative to the requirements of growing pigs. Research work in a number of laboratories world wide has as its objective enhancing the level of the limiting amino acids in the grain protein and yet retaining high yields of grain.ha^{-1}. An alternative approach is the supplementation of the grain with commercial sources of the three amino acids, developed with the assistance of biotechnology.

- There are numerous examples of the use of plant-breeding to remove anti-nutritional constituents from feed sources; one is the β glucans of barley grain.
- With roughage, developments in the production of commercial sources of enzymes such as cellulases and xylanses, and possibly lignases, some of them modified by genetic engineering to be even more effective than the naturally - occurring enzymes are likely to lead to new techniques for enhancing the digestibility and hence nutritive value of low quality roughage such as straw.

(ii) Improvements in the digestive capabilities of farm livestock: Mention has already been made of the use of commercially produced enzymes to enhance the feed conversion efficiency and/or availability of nutrients such as P by pigs and poultry. Considerable research interest is currently being shown in the potential of some of the new technologies, particularly that of recombinant DNA to effect modifications to the rumen microbial ecosystem with the objective of increasing efficiency of digestion and/or feed utilisation in ruminant livestock.

(iii) Manipulation of mammalian metabolism: The creation of transgenic livestock or the production of hormones and growth factors which effectively increase yield of meat or milk or affect the quality of the product (i.e. alter the protein to fat ratio in meat) may well lead to changes in nutritional requirements and hence necessitate changes in feed formulation.

(iv) The introduction of novel feed sources: A number of feed protein sources originating from the growth of micro-organisms are or have been studied. The most well known is 'Pruteen', developed by ICI for the feed industry and based on the micro-organism *Methylophilus methylrophus* grown on methanol as a substrate. Efficiency of growth of the micro-organism has been improved by the use of recombinant DNA technology to introduce a more efficient pathway for the incorporation of ammonia used as the source of nitrogen. The product was increasingly used by the feed industry as a source of protein in diets for broilers, piglets and preruminant calves, as well as fish. At the present time the production of 'Pruteen' has been suspended owing to the rise in world price of methane gas - the source of methanol - making the process uneconomical.

Concluding remarks

From a consideration of but four areas of knowledge out of very many such that exist, it would appear obvious that feed manufacturing conferences such as this one have much to offer those engaged in the industry. The wide range of topics to be discussed requires that the programme chosen for each such conference must be selected by co-operation between those engaged in the Industry and scientists employed in institutes of learning who are familiar with the livestock feed industry.

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