ROSS

ROSS TECH 03/41

NUTRITION AND ENTERIC HEALTH

Maintaining good litter quality is critical for successful broiler rearing especially during the more challenging winter months. However opportunities exist for the nutritionist to influence litter conditions.

Litter quality will be influenced by any enteric related disorders and may be related to the removal of antibiotic growth promoters and the removal of animal proteins and fishmeal from broiler diets in some countries. The degree and severity of disorders can vary depending on the region, the poultry operation and the time of year.

Two principle enteric conditions have been identified, *Necrotic Enteritis* caused by Clostridia perfringens and *Dysbacteriosis* which is defined as a general overgrowth of microflora in the intestine.

'Alternative' growth promoters have been evaluated and some continue to be used by several poultry companies. These products include prebiotics, probiotics, pathogen binders, organic acids and essential oils, with some products containing various combinations. The industry has evolved a strategy combining different approaches to controlling enteritis rather than relying on one 'alternative' product as a panacea.

The emphasis is now on farm managers adopting a proactive approach to enteric health, involving early detection of disease and prompt treatment, along with an emphasis on sound environmental management.

The role of the nutritionist in preventing enteritis has become even more critical; the support provided by antibiotic growth promoters must now be replaced by feeding enteric friendly diets.

The concept behind feeding for enteric health is principally to attain a stable microflora population within the intestine. Such a stable microflora population should minimise enteric disorders and be associated with high productivity. Consideration should be given to the effect of nutrients on intestinal microflora, namely protein and amino acids, energy from either starch or fat, fibre, dietary mineral levels and electrolyte balance.

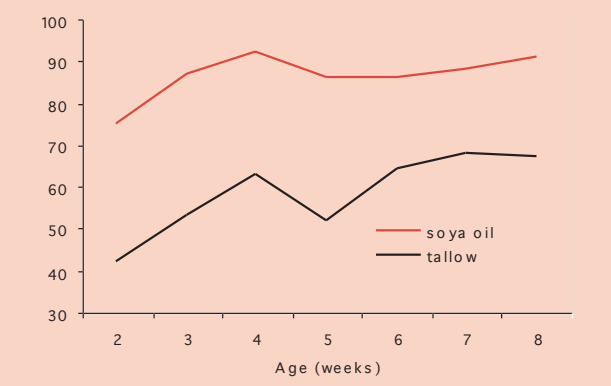
The effect of specific raw materials, feed additives and feed processing techniques are highlighted and include cereals, optimal use of feed enzymes, fats, feed grist size, gizzard development, pelleting and extrusion.

NUTRITIONAL FACTORS AFFECTING ENTERIC CONDITION

SOURCE OF FAT IN DIETS

It is well established that different fat sources have different digestibility coefficients. Fats with a higher content of unsaturated fat relative to saturated fat tend to have a higher digestibility. Figure 1 shows the effect of fat digestibility when comparing two different sources, tallow representing a saturated fat and soya oil representing an unsaturated fat. Soya oil has a higher digestibility than tallow; it can also be noted that younger birds do not digest fats or oils as well as older birds.

Figure 1: The effect of age on digestibility (%) of fats in broilers.



Ketels 1994

It has been demonstrated experimentally that the effect of a xylanase based enzyme, in a wheat and rye based diet, in terms of growth, is strongly influenced by the type of fat in the diet (see Table 1). There was also a higher intake of water in the animal fat diet compared to the soya oil diet; this may potentially increase litter moisture content.

Table 1: The effect of supplementation with an endo-xylanase preparation on broiler chick performance and water intake in relation to the fat source (1 to 21 days of age)

Group	Fat Source	Enzyme Addition	Weight Gain (g)	Food intake (g/bird/day)	Water to feed ratio
1	Soya Oil	–	663[b]	48.7	1.88
2	Soya Oil	+	638[b]	47.3	1.88
3	Animal Fat	–	567[a]	47.2	1.97
4	Animal Fat	+	621[b]	48.6	1.95

Langhout 1998

It is known that fat affects the retention time of the feed in the small intestine. Unsaturated fatty acids increase the time that the chyme (intestinal contents) spends in the small intestine. It is suggested that these fats stimulate the reflux of the chyme from the duodenum to the gizzard. Therefore, it can be speculated that the type of fat will not only affect digestibility but may also influence the microbial activity in the small intestine. Unpublished work at ILOB in the Netherlands analyzed the microbial activity in the ileum of birds fed a diet containing either 10% soya oil or 10% animal fat. The birds fed on the soya oil diet had a lower total microbial activity in the ileum than the ones

fed on the animal fat containing diet. Feeding a saturated fat may have a negative effect on the stability of microflora compared to unsaturated fat. Destabilizing the enteric microflora may well lead to enteric conditions.

The key point is to aim to use digestible fat sources especially in starter diets.

PROTEIN LEVELS IN THE DIET

Excessive levels of dietary protein supply must be catabolised and excreted via the kidneys as uric acid. This will involve higher water consumption. As a guide an increase in protein level of one percentage point increases water consumption by 3%. This effect on water intake may be due to the increase in protein content, but may also reflect an increase of potassium from soyabean meal. In most diets soyabean is the main contributor of protein and also contains a significant amount of potassium relative to other raw materials. High levels of potassium increase bird water intake, which can lead to increased water excretion. Therefore feeding higher levels of protein via soyabean products increases the potassium content of the diet which in turn increases water consumption and moisture content of excreta. See section on mineral levels in diets.

It should be noted that wet litter may be due to excess excretion of water by the kidneys as opposed to just soft droppings.

Formulating diets on digestible amino acids rather than crude protein and total amino acids has been shown to be beneficial in reducing nitrogen excretion and hence improving litter quality. Excessive protein intake increases water intake as nitrogen is deaminated in the kidneys and excreted as uric acid.

Minimise the levels of excess protein in diets by formulating to digestible amino acids

STARCH DIGESTIBILITY

Recent research indicates that different starch sources in the diet are digested at different rates and that this impacts on bird growth. Researchers have fed birds two different diets, one containing a higher and the other a lower proportion of fast degradable starch. Birds fed a higher proportion (see Table 2) of slowly digested starch performed better than those fed less slowly digestible starch. Slowly digestible starch is said to improve the efficiency of digestion of protein and amino acids.

Table 2: Body weight, weight gain, feed intake and FCR of female broiler chickens receiving either high (H) or low (L) amounts of slowly digestible starch (SDS) (n=6)

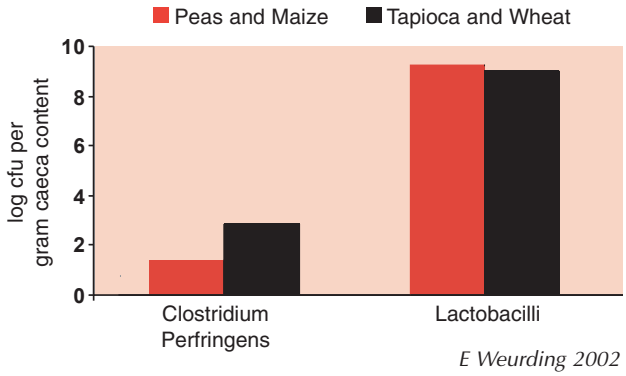
Period	Parameter	H	L	SEM	Starch effect P-value
0 to 38 days	Bodyweight (g)	1823	1729	13	<0.01
	Feed intake (g)	3093	3002	32	0.07
	FCR	1.734	1.777	0.009	0.01

P.J. van der Aar et al 2003

The rate of starch digestion may not only exert an effect on the amino acid utilization in the small intestine but it may also effect the composition of the microflora. Experiments feeding birds slowly degradable starch (based on peas and maize) showed a different profile of microflora, less Clostridium perfringens, which is associated with necrotic enteritis, and a trend towards more favourable Lactobacilli bacteria when compared to birds fed faster digested starch (based on tapioca and wheat).

It is suggested that the rate of starch digestion and absorption of amino acids may influence the availability of substrate for caecal microflora growth (see Figure 2).

Figure 2: Effect of Diet Formulation and Processing on Bacterial Counts in the Caeca of Broiler Chickens



E Weurding 2002

It has also been shown that feed conditioning can have a dramatic effect on the rate of starch digestion; it would appear that the more severe the heat treatment the faster the rate of starch digestion. This moderation of starch digestion may well affect microflora growth.

Recent work has shown significant differences in the digestion of starch in different parts of the small intestine (see Table 3). It has been suggested that raw materials could be categorised as either slow or fast digested raw materials.

Table 3: Digestion coefficients of starch in different segments of the small intestine of broiler chickens fed diets containing different starch sources

Starch Source	Posterior jejunum	Anterior ileum	Posterior ileum	Total tract
	Ingested starch			
Wheat	88.2	92.9	94.4	93.8
Maize (hammer milled)	88.8	95.3	96.9	97.4
Barley	89.8	97.3	98.1	98.3
Beans	36.1	62.9	72.3	74.5
Sorghum	83.7	93.0	95.3	95.4
Peas	57.4	73.0	80.4	81.0
Horse beans	57.0	74.8	81.5	81.5
Tapioca Pellets	97.7	98.7	98.9	98.9
Raw Potato Starch	19.8	25.3	32.9	31.7

E Weurding 2002

The principle point is that nutritionists should perhaps give consideration not only to the digestibility of starch from raw materials but also to the rate of digestion and the effect of intestinal microflora.

MINERAL LEVELS OF DIETS

Potassium is involved in maintenance of water and acid base balance of the blood. It is well known that increased potassium levels in diets beyond a certain level increases water intake. It is generally regarded that potassium levels above 0.9% in diets result in excessive water intake. Experiments which involved increasing levels of potassium in feed showed a clear increase in water intake. Nutritionists generally limit the level of potassium in diets by placing a maximum specification nutrient level between 0.90 to 0.95%.

The main contributors of potassium to the diet are soya products, it is therefore important to minimise the content of these products in diets. To avoid excessive levels of potassium in the diet normal maximal inclusion level of soya products is approximately 35%.

Like potassium, sodium has an effect on water consumption, this is particularly the case when higher levels of sodium are attained by supplementation with sodium chloride. Generally levels of sodium higher than 0.24 have been associated with increased excreta moisture content.

ELECTROLYTE BALANCE

Electrolytes maintain body water and ionic balance, birds will regulate the balance of blood electrolytes so as to maintain a constant physiological pH. The primary modulators of the birds electrolyte balance are sodium, potassium and chloride. Nutritionists calculate a dietary electrolyte balance based on these three elements. The guideline is for the Mongin equation to result in a figure of approximately 250 mEq/kg. More recent research would suggest the optimal dietary electrolyte balance between 246 to 315 mEq/kg in the starter phase and 249 to 257 in the grower period. Other work suggests quite different optimal dietary electrolyte levels to optimise either weight gain and feed conversion ratio, 236 and 207 respectively. The target electrolyte balance for broiler feeds is by no means established however, nutritionists should aim to meet the existing recommended electrolyte balance of 250 mEq/kg.

RAW MATERIALS AFFECTING ENTERIC CONDITION

CEREALS

Cereals contain fibres called non starch polysaccharides, some of which are water soluble and contribute to the viscosity of the intestinal contents. Increased intestinal viscosity results in reduced nutrient digestion and absorption, an increase in water consumption resulting in increased excreta moisture content and poor litter conditions. Cereals vary in the levels of these non starch polysaccharides (see Table 4) maize containing the lowest levels of NSPs and barley the highest. Certain NSP's will have more of an effect on intestinal viscosity than others; beta glucans and arabinoxylans having the greatest effect. The type of NSP will alter in different cereals, barley containing higher levels of beta glucans compared to other cereals. Hence wheat and barley based diets tend to have more impact on intestinal viscosity than other cereals.

Table 4: The Non Starch Polysaccharide Content of Cereals

	Barley	Maize	Wheat
Arabinoxylan (g/kg)	65	44	58
Beta Glucan (g/kg)	40	-	7

EXOGENOUS ENZYMES

Exogenous enzymes are used in wheat and barley based diets and in some maize soya diets. These enzymes cleave large complex carbohydrates reducing the viscosity and indirectly controlling microflora development. As a result they:

- increase the digestibility of nutrients, such as energy, protein (amino acids), fat in particular and minerals.
- reduce stickiness or oiliness of the excreta.
- improve litter quality by reducing water excretion.

Consideration should be given to the use of an appropriate enzyme depending on what raw materials are being used. Broiler diets change in raw material composition due to cost, legislation or availability. This may affect the level and type of NSP's in the diet. There has been a trend in some countries for removal of animal proteins and increased use of vegetable proteins e.g. soyabean meal or peas. It is important that the nutritionist evaluates the efficacy of the enzyme in use, selects an enzyme with an appropriate activity, and avoids sudden changes in cereal type.

Recommendations when selecting an enzyme:

- The dose and activity are based on performance data not *in vitro* work.
- The enzyme should work optimally at a physiological pH of a wide enough range to survive a low pH in the intestine.
- The source organism and doses should be stated, plus International Enzyme Number and Registration Code.
- Look for stability data related to conditioning temperatures and dwell time.

GRIST SIZE OF MATERIALS AND GIZZARD STIMULATION

When feeds have more structure, either through the use of whole cereals, larger grist size or through the addition of large fibre particles (for example oat hulls), gizzard size increases. Stimulation of gizzard activity has an effect on gastro-duodenal refluxes and proventricular activity. The figure below shows the effect of whole and ground grain in the diet on gizzard development. (See Figure 3). Research has also shown an improvement in starch digestibility and delayed intestinal transit time when feeding coarse insoluble fibre.

Figure 3: The effect of whole and ground wheat on gizzard development in broilers.

Whole Wheat

Ground Wheat

Hetland et al 2003

There may be benefits in using whole wheat to stimulate gizzard function, however to maintain optimal performance the use of a balancer diet is recommended.

The key point is that opportunities may exist which nutritionists and feed manufacturers could take advantage of in current commercial diets.

GRINDING OF RAW MATERIALS

In a study in which birds were inoculated with Clostridium perfringens to induce necrotic enteritis there was some evidence to suggest diets containing roller milled wheat reduced mortality in broilers when compared to a diet containing hammer milled wheat (see Table 5).

The differences in mortality were attributed to the particle size of the milled raw materials. The roller milled wheat consisted mostly of granular particles, with only 7.3% of flour particles and the hammer milled wheat contained 22.7% flour-like material. It could be hypothesised that the coarser particle size increased gizzard function which, as previously mentioned, can increase digestibility.

The key point from this data is to aim to reduce the degree of fines in commercial feeds especially in wheat based diets, this would appear particularly important in a growth promoter free environment.

Table 5: The effect of grain component of diet and method of grinding grain on broilers infected with necrotic enteritis caused by Clostridium Perfringens and Coccidiosis

Treat-ment	Diet Description		42-day Performance		
	Grain	Grinder Type	Weight	Feed Weight	Mortality
1	Maize	Hammer	1.749	1.946	2.9
2	Wheat	Roller	1.733	1.834	18.1
3	Wheat	Hammer	1.659	1.861	28.9
4	Maize/ Wheat	Hammer/ Roller	1.765	1.902	3.4
5	Maize/ Wheat	Hammer/ Hammer	1.757	1.871	12.6

Branton et al 1987

TECHNOLOGICAL TREATMENTS

Extrusion and pelleting have been known to have an effect on water consumption in birds fed barley. The water to feed ratio increases when pelleting temperatures are increased from 60 to 90°C. The increase in water intake followed the same pattern of increase in feed viscosity of birds fed on a wheat based diet; this is thought to be due to an increased solubility of NSPs as temperature increases. This reinforces the need for use of enzymes when using wheat or barley based diets.

VEGETABLE PROTEINS

Use of vegetable proteins has increased in those regions where animal proteins and fishmeal have been removed. Vegetable protein ingredients contain indigestible carbohydrates such as oligosaccharides which can lead to poor nutrient digestion and absorption. There is a tendency towards increased enteric issues and digestive disorders which will effect water consumption and moisture content of droppings.

Table 6: Primary plant ingredients used in poultry diets and some compounds in them which may cause adverse effects on intestinal health

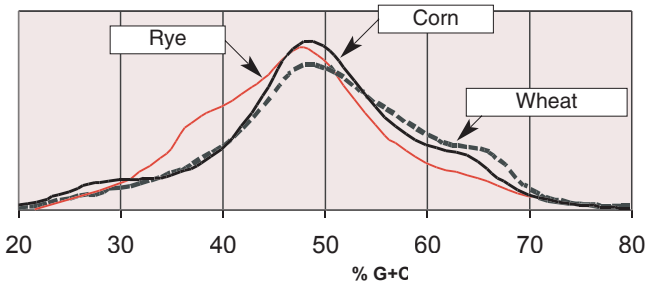
Ingredient	Some potential problem compounds
Maize	Lectins, phytate, resistant starch
Wheat	Arabinoxylans, wheat germ agglutinin, phytate, resistant starch
Barley	Beta glucans, resistant starch
Rice	Phytate, arabinoxylans
Sorghum	Tannins, resistant starch
Rye	Arabinoxylans, polyphenols
Soyabean meal	Oligosaccharides and NSP's, trypsin inhibitors, lectins
Peas	Resistant Starch, proteins, saponins
Beans	Tannins, trypsin inihibitors, lectins, oligosaccharides, NSP's
Lupins	Oligosaccharides, NSP's, proteins
Rapeseed meal	Oligosaccharides, NSP's, tannins, glucosinolates
Sunflower meal	Oligosaccharides, NSP's

NSP, Non-Starch Polysaccharide. Acamovic 2001

THE FUTURE

Recent research indicates that microflora populations of the intestine may be measured. The graph below shows the effect of different cereals on intestinal microflora based on a measurement of cacal bacteria DNA. The profile of microflora populations in the caecum can be established by measuring the percentage of specific bacteria DNA, % G+C. It is apparent that the profile of microflora changes according to the cereal fed. Potentially the effect of feed additives and raw materials could be quantified.

Figure 4: Mean profile of the caecal microbial community in broiler chickens fed wheat, corn and rye based diets.



Apajalahti, J. and Bedford, M. (2000)

In conclusion:

- More information is required for the nutritionist to evaluate the effect of raw materials and feed processing techniques on micro flora stability.
- Recent research indicates that the microflora populations of the intestine may be measured and potentially the affects of feed additives and raw materials could be quantified.
- In the meantime there appear to be areas where the nutritionist and the feed mill operation can enhance the effectiveness of the diet from an enteric health point of view.

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Aviagen Limited
Newbridge
Midlothian
EH28 8SZ
Scotland
UK

tel: +44 (0) 131 333 1056
fax: +44 (0) 131 333 3296
email infoworldwide@aviagen.com

Aviagen Incorporated
Cummings Research Park
5015 Bradford Drive
Huntsville
Alabama 35805
USA

tel: +1 256 890 3800
fax: +1 256 890 3919
email info@aviagen.com

website www.aviagen.com

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