No.23 October 1999

FISH MEAL FLYER

FISH OIL REDUCES PERFORMANCE LOSS DUE TO COCCIDIOSIS IN BROILER CHICKS

Summary and Conclusions

Incorporation of omega-3 fatty acids in the diet of chicks challenged with coccidiosis (*E. tenella*) reduced the adverse effects on growth and reduced gut lesion scores. The optimum response with fish oil was seen with 5%. Lower levels of fish oil (2.5%) gave lower yet significant improvements. It was demonstrated that the main long chain omega-3 fatty acids in fish oil (EPA plus DHA) accounted for most of the fish oil's activity. One suggested mode of action is that the omega-3 fatty acids infiltrate tissues of the parasite which become more susceptible to oxidative attack by phagocytic cells. It is believed that *E. tenella* may be particularly susceptible. In addition the effects of omega-3 fatty acids may be via the immune system, reducing the effect of inflammation.

Where coccidiostats are not used and a coccidiosis challenge is likely to be high and/or resistant strains of coccidia build up - a high level of fish oil in the diet (5%) would be required but perhaps only for a few days. Where a coccidiostat is used and/or the challenge is small - lower levels (1% to 2%) should be effective. Vegetable oils such as flax (linseed) which are high in 18 carbon omega-3 fatty acids (linolenic) are less effective, even when used at high dietary inclusions (e.g. 15% flaxseed).

Coccidia in Poultry - the Losses

Coccidiosis is a disease of poultry caused by protozoan parasites of the species *Eimera*. It results in gastro-intestinal tract (GI) lesions, which reduce nutrient absorption, and it decreases performance. In more severe cases, mortality can result. It is widespread in poultry and has been estimated to cost the USA poultry industry more than $300 millions annually. Part of this is the cost of prophylactic medication (about $90 millions) with anticoccidial drugs. Many of these have diminished effectiveness because of the emergence of new strains that are drug resistant. Consequently, new approaches for the control of coccidiosis are being sought. Manipulation of the diet and use of natural ingredients are being investigated.

Mode of Action[1]

Different strains of *Eimera* exist, and these attack different parts of the GI. *E. acervulina* develops in the duodenum, *E. maxima* in the mid small intestine and *E. tenella* invades the caeca. When a cell is attacked by coccidia an immune reaction is mounted in defence. This tends to be pro-inflammatory. Whilst it is essential such a reaction occurs rapidly, it tends to increase the growth suppressing effects of a coccidial infection probably by suppressing appetite. Dietary factors could alter these changes.

Dietary Nutrients/Feed Ingredients which may Affect Losses due to Coccidiosis

There is increasing interest in diet manipulation and use of natural ingredients to control coccidiosis. Several dietary treatments have been shown to have beneficial effects on chickens infected with coccidia (1). In addition, products supplying omega-3 fatty acids, particularly fish oil, have also been shown to have beneficial effects (2, 3). Indeed fish oils were found to be the most effective, followed by products with antioxidant properties such as α tocopherol and the spice tumeric (1). Unlike most of the other treatments, fish oil appears to have a direct effect on the parasite (1).

Effect of Omega-3 Fatty Acid Supplementation of the Diet on Coccidiosis

Protozoan parasites - both *Plasmodium* (malaria) and *Eimeria tenella* (coccidiosis) can be controlled by inclusion of omega-3 fatty acids in the diet. The effect of coccidiosis in broiler chicks was investigated following the earlier finding that these fatty acids afford some protection against malaria (4). Total plasma carotenoids fall with coccidia activity in the host (2, 5), and levels of free radicals (for example, peroxynitrite measured as increased levels of the end products of nitrite and nitrate in the blood) increase (6). It is postulated that the highly unsaturated omega-3 fatty acids - docosahexaenoic (DHA), eicosapentaenoic (EPA) and linolenic acid - create oxidative stress which adversely affects development of coccidia. It has been suggested that the unsaturated fatty acids are incorporated into the membranes of coccidia or *Plasmodium*. For both parasites, growth involves a continual turnover of their membranes, the composition of which will be influenced by dietary fatty acids. There they will be highly susceptible to oxidation by free radical production of leucocytes which bombard the coccidia (6, 7).

Fish oils are also anti-inflammatory through the changes they bring about in the eicosanoids. They have been shown to decrease inflammatory cell production of LTB_4 (8) and increase production LTB_5 (9) in mammals. The LTB_5 produced from omega-3 (n-3) fatty acids is only 1/8th as potent a chemoattractant as the LTB_4 from omega-6 (n-6) fatty acids, the former reducing the recruitment of pro-inflammatory agents, that is, it is less inflammatory. In poultry, fish oil feeding has also been shown to result in reduced production of the pro-inflammatory cytokines, IL-1 and TNFα (see Appendix and ref (10)).

Effect of Dietary Omega-3 Supplementation on Performance of Broilers Infected with Coccidia

Adding 5% fish oil to a basal diet significantly reduced GI lesion score (Table 1, from (2)). Microscopic examination revealed a striking reduction in the number of parasites seen within the the epithelial cells of the caeca. Increasing fish oil to 10% gave no further improvement in lesion score. In this trial infection with coccidia did not reduce live weight gain and thus addition of fish oil had no effect on gain.

Addition of 10% medium chain triglycerides as an energy control had no effect on lesion score in this trial. Flax and linseed (sources of carbon 18 omega-3 fatty acids [linolenic acid]) reduced lesions when included at 10%, but not as effectively as 5% fish oil. In a further trial with lower levels of fish oil, lesion score was reduced to a small extent, non-significant, by 1% inclusion while 2.5% and 5% gave progressively greater reductions (Table 2, (3)). Weight gains were variable and in general infection did not significantly reduce weight gain. The only exception was an apparent reduction of infection in the presence of 2.5% fish oil but this was due to the exceptionally good performance of the uninocculated chicks at this level of oil inclusion.

Working with esters of EPA and DHA, Allen *et al* (2) compared these separately and together, and also with fish oil (5%). Amounts of EPA and DHA were

[1] A more detailed account of the mode of action of coccidia and the resultant immune reaction is given in Appendix 1

equivalent to those provided by 5% fish (menhaden) oil. Similar significant reductions of lesion scores were seen with EPA plus DHA or fish oil, but not with the separate fatty acids which gave small non-significant differences. Both EPA and DHA reduced plasma carotenoids in uninfected chickens indicating they promoted a state of oxidative stress.

Fish oil was compared with corn oil in chicks infected with *E. tenella* by Korver, Wakenell and Klasing (10) at the University of Davis. The oils were included in the diet at 4%. Lesion scores were reduced but not significantly by fish oil. However, fish oil decreased plasma TNFα — 24.8 v 46.4 indicating reduced inflammatory processes but protective responses such as an increase in the acute phase protein hemopexin which binds released haem groups were enhanced by fish oil. Whereas chicks fed corn oil showed reduced weight gain as a result of the coccidiosis challenge (37.6 v 33.0 g/day), the fish oil fed birds did not (35.9 v 38.1 g/day) resulting in a statistically significant diet x infection interaction. These changes in growth rate were reflections of similar changes in feed intake. These authors concluded that the benefit of fish oil comes at least in part from blunting systemic responses of the chicks to pro-inflammatory mediators.

Response of chickens infected with other strains of coccidia (*E. acervulina* and *E. maxima*) showed little if any response to dietary supplementation with fish oil. There were some indications of reduced lesion score with *E. maxima* (5% menhaden oil 3.1 v control 3.6; (11)), but differences were not significant. There was an indication that with 15% whole flaxseed in the diet broilers infected with *E. maxima* had reduced weight gain (153 v 191g) and higher lesion scores (4.0 v 3.6) than the unsupplemented controls (11).

APPENDIX 1

Mode of Action of Coccidia

When a cell is attacked by coccidia the resulting immune reaction is primarily mediated by pro-inflammatory phagocytic cells. These white blood cells (leucocytes) are recruited to the site of inflammation where they produce free radicals which kill the invading cells (Rice-Evans, (12)). They are also the source of pro-inflammatory mediators such as the proteins interleukin-1 (IL-1) and tumour necrosis factor (TNFα). These cytokines cause a reduction in feed intake and reduced weight gain (9).

In mammals, leukotriene B_4 (LTB_4), synthesised from the fatty acid arachidonic acid, plays an important role in the immune reaction, recruiting immune cells to the site of infection. While this is essential to mount a quick response it also causes an influx of pro-inflammatory cells and an increase in the release of pro-inflammatory mediators. In poultry this would increase the growth-suppressing effects of a coccidial infection.

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TABLE 1

EFFECTS OF DIETARY SUPPLEMENTATION WITH FISH OIL ON WEIGHT GAINS AND LESION SCORES IN BROILERS INFECTED WITH *EIMERIA TENELLA*[1]

Dietary Group[2]	Birds per group (n)	Supplement level (%)	Parasite treatment	Weight gain (g)	Lesion score
SS	10	0	Uninfected	233 ± 8^{ab}	0^{d}
	10		Infected	238 ± 6^{ab}	1.95 ± 0.27^{a}
MCT	10	10	Uninfected	217 ± 13^{b}	0^{d}
	10		Infected	214 ± 12^{b}	1.7 ± 0.26^{a}
FO	10	5	Uninfected	244 ± 6^{ab}	0^{d}
	10		Infected	241 ± 6^{ab}	0.11 ± 0.11^{cd}
	10	10	Uninfected	219 ± 11^{b}	0^{d}
	10		Infected	213 ± 9^{b}	0.3 ± 0.3^{cd}
FLX	10	10	Uninfected	249 ± 10^{ab}	0^{d}
	10		Infected	248 ± 12^{ab}	1 ± 0.36^{b}
LIN	10	10	Uninfected	265 ± 12^{a}	0^{d}
	10		Infected	225 ± 21^{a}	0.7 ± 0.21^{bc}

TABLE 2

EFFECTS OF DIETARY SUPPLEMENTATION WITH VARYING LEVELS OF FISH OIL ON WEIGHT GAINS AND LESION SCORES IN BROILERS INFECTED WITH *EIMERIA TENELLA*[3]

Dietary Group[2]	Birds per group (n)	Supplement level (%)	Parasite treatment	Weight gain (g)	Lesion score
SS	10	0	Uninfected	267 ± 8^{bc}	0^{c}
	10		Infected	229 ± 13^{c}	3.2 ± 0.2^{a}
MCT	10	10	Uninfected	253 ± 10^{c}	0^{c}
	10		Infected	258 ± 17^{bc}	2.4 ± 0.27^{bc}
FO	10	1	Uninfected	302 ± 9^{ab}	0^{c}
	10		Infected	267 ± 10^{bc}	2.9 ± 0.18^{ab}
	10	2.5	Uninfected	316 ± 8^{a}	0^{c}
	10		Infected	268 ± 10^{bc}	2.2 ± 0.36^{c}
	10	5	Uninfected	270 ± 24^{bc}	0^{c}
	10		Infected	242 ± 11^{c}	1.44 ± 0.41^{d}
	10	10	Uninfected	277 ± 12^{abc}	0^{c}
	10		Infected	272 ± 18^{abc}	1.56 ± 0.41^{d}

[1]From (1)

[2]SS=basal starter ration; MCT=medium chain tryglycerides; FO=fish oil; FLX=whole flaxseed oil; LIN=linseed oil

[3]From (3)

[a-d]Values represent the means $\pm$SEM of n birds in one replicate. Means within a column with no common superscript differ significantly ($P < 0.05$)