International Fishmeal & Oil Manufacturers Association

HEALTHIER MEAT FROM BEEF: FEEDING FISH OILS

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SUMMARY

Preliminary results of trials with beef cattle show that as well as increasing the content of healthy long chain omega-3 fatty acids in meat, fish oil feeding may improve meat quality. However, there appears to be a narrow margin between the level of fish oil in the diet needed to improve meat quality and a level at which meat quality deteriorates.

In view of the huge new potential market that such a development could open, it is recommended that follow up work is initiated at the earliest opportunity.

Background

The UK beef industry is struggling to survive the BSE crisis. In an attempt to rebuild the image of meat when the BSE crisis is over, the UK Ministry of Agriculture is investing around a million pounds sterling in projects to improve the healthy image of beef and lamb. The aim is to increase unsaturated fatty acids in meat by dietary means. Fish oil and linseed oil, both sources of highly unsaturated omega-3 fatty acids are being compared. The former has long chain (C_{20} and C_{22}), and the latter short chain (C_{18}) as the predominant fatty acids.

Work is now in progress with beef cattle at the Institute of Grassland and Environmental Research (IGER) in Aberstwyth, Wales, and with lambs at Harper Adams Agricultural College at Newport, Shropshire, England. The meat from the animals is being assessed for organoleptic properties (taste, texture, etc.) by the Food Science department of the University of Bristol. The Food Science Department of the University of Reading is studying the chemical make-up of the flavour components in the meat.

Preliminary results from the beef work which are interesting and somewhat unexpected are reported here. Results are not yet available from the lamb work.

Beef Growth Trials

Charolais cattle (32), weighing approximately 400kg, were fed grass silage and a barley/sugar beet concentrate containing either saturated protected fat (Megalac), fish oil, linseed oil (as whole linseed) and fish oil/linseed oil. The concentrate contained 25g/kg of each oil, or mixture (see Table 1).

Results

The fish oil treatment resulted in slightly lower feed intake, though the difference was not significant. Liveweight gains were not affected by the dietary treatments (see Table 2).

The fish oil treatments produced both the best and the worst meat quality (see Table 3). The fish oil/linseed oil mixture (45g fish oil per animal) produced meat which was generally of better flavour, texture and overall liking, though the difference was not significant. On the other hand, the meat from animals fed the higher level of fish oil - 87g per animal, had significantly poorer texture and overall liking.

As expected, fish oil increased the long chain unsaturated omega-3 fatty acid content (especially EPA and DHA) in the meat. There was a surprising content of these fatty acids in meat from animals which received no fish products - 35mg per 100g muscle. This was increased to 41mg with fish oil/linseed oil and 52mg with fish oil at the higher level.

The degree of oxidation of lipids in the muscle were measured by TBA values (aldehydes). These were higher for the high fish oil treatment than the controls, whereas they were not elevated by the lower level of fish oil - in the fish oil/linseed oil treatment. Headspace analysis of the components of lipids extracted from muscle showed elevated levels of unsaturated aldehydes. Thiazolines and 2, 4-Nonadienal were elevated, possibly accounting for off-flavours of meat from the high fish oil treatment.

Discussion

It is now known that a large proportion of the unsaturated fatty acids from fish oil escape hydrogenation in the rumen. The fact that the long chain omega-3 fatty acids from fish oil were deposited in muscle tissue is not unexpected. What was surprising in this work is that at low levels fish oil may improve beef quality in terms of taste and texture as well as making it more healthful by increasing these fatty acids in muscle tissue. The work would indicate a narrow margin between the level of fish oil improving meat quality and that reducing quality (45g v 87g per animal, respectively). There may be a benefit in combining fish oil and linseed oil though linseed oil alone was disappointing in that it led to little increase in polyunsaturated fatty acids in the meat. It may have been extensively hydrogenated in the rumen - this has been shown to occur with unsaturated vegetable oils.

It is interesting that the long chain omega-3 fatty acids from fish oil (EPA and DHA) are deposited in muscle rather than adipose tissue. This is because they go into phospholipids within the muscle cell structure. It is possible that in so doing, at a low level they may improve muscle texture, leading to more tender beef.

It should also be noted that long chain omega-3 fatty acids are present in meat even where no fish products are fed. It is believed that these may arise from omega-3 fatty acids in fresh forage which to a limited extent may escape hydrogenation in the rumen - perhaps because of incomplete fibre digestion. Subsequently (at a tissue level?) they could be chain elongated. Evidence shows that on low forage diets or with poor quality forage, fresh or preserved, these fatty acids are not present in meat so it could be argued fish oil restores a more 'natural' fatty acid profile. Purists, however, would argue it is not natural to feed marine products to herbivores!

It is recommended that more work is undertaken to confirm the findings. With a world cattle population of 1.2 billion, feeding 45g fish oil per day to each of these to improve meat could provide a huge potential market. With approximately one quarter in developed countries, the potential market here is approximately five million tons per annum! There is also some evidence fish oil may improve health of cattle - this should be explored further.

TABLE 1

Formulation of experimental diets (kg/tonne DM)

	Control	Linseed	Fish Oil	Linseed/Fish Oil
Barley	632.4	482.8	630.4	555.8
Sugarbeet	218.1	217.1	225.3	220.8
Molasses	53.9	53.7	55.7	54.6
Megalac	71.1	-	-	-
Fish oil	-	-	63.3	29.8
Linseed	-	222.0	-	114.2
Premix	24.5	24.4	25.3	24.8
Estimated Nutrient intake g per kg total diet (silage + concentrate).				
Oil	53.1	52.8	52.2	52.5
Added Oil	23.3	24.4	22.9	23.6

Composition of experimental diets (g/kg DM unless otherwise stated)

	Silage	Control	Linseed	Fish Oil	Linseed/Fish Oil
DM (g/kg fresh)	25.8	90.4	90.2	90.6	90.1
pH	3.70	--	--	--	--
Total-N	22.6				
NH_3-N	1.44	--	--	--	--
Soluble-N	13.93	--	--	--	--
ADIN	0.738				
OM	92.1	927.8	933.9	941.3	933.5
NDF	474.9				
ADF	282.8	86.4	108.4	92.3	99.9
WSC	14.54				
Starch	-				
AHEE	-	77.3	106.5	82.4	96.9
Lactic acid		--	--	--	--
Acetic acid	29.58	--	--	--	--

DM - dry matter
ADIN - acid digest insoluble nitrogen
OM - organic matter
NDF - neutral detergent fibre
ADF - acid detergent fibre
WCS - water soluble carbohydrate
AHEE - acid hydrolysis ether extract

TABLE 2

IGER/BRISTOL BEEF TRIAL 1995/96

Feed Intake/Growth

	Control	Linseed	Fishoil	LinsFish	SEM
Forage DMI (kg/d)	5.43	5.43	5.12	5.37	0.175
Conc. DMI (kg/d)	3.61	3.62	3.46	3.60	0.116
Forage DMI (g/kg Lwt)	11.01	10.87	10.51	10.75	0.252
Conc DMI (g/kg Lwt)	7.30	7.24	7.05	7.20	0.160
Liveweight (kg/d)	1.38	1.35	1.43	1.43	0.067
Rate of Forage DM decline	-0.0315 (1:31)	-0.0261 (1.28	-0.036 (1:38)	-0.035 (1:27)	0.0049
Rate of Conc. DM decline	-0.0187 (1:53)	-0.0227 (1:44)	-0.0202 (1:50)	-0.0243 (1:41)	0.0029

DMI - dry matter intake
Conc - concentrate, i.e. cereals and proteins

TABLE 3

Influence of Diet on the Eating Quality of Grilled Beef Loin Steaks

Values are the means derived from analysis of variance using diet as a factor and assessors and panels as a 'block' structure for eight replications.

Attribute	Diet				sed	sig
	Fish Oil	Control	Linseed	Fish/linseed		
Texture	4.6[a]	5.0[b]	5.1[b]	5.2[b]	0.167	**
Juiciness	4.5	4.5	4.9	4.7	0.158	ns
Beef flavour intensity	3.5	3.8	3.8	3.8	0.169	ns
Abnormal flavour intensity	3.2	2.8	2.9	2.9	0.185	ns
Hedonic						
Flavour liking	4.2	4.4	4.5	4.7	0.184	ns
Overall liking	3.9[a]	4.4[b]	4.5[b]	4.6[b]	0.170	***

TABLE 4

MAFF BEEF CONTRACT

Effect of feed fat on the fatty acid content of the total lipids of the longissimus dorsi muscle.

		mg per 100g muscle					
Fatty acid	Feed:	Control[1]	Linseed	Fish oil	Fish oil + Linseed	SED	P
12:0		3.20	3.79	3.70	4.36	.789	NS
14:0		121	152	173	169	34.0	NS
16:0		1029	1089	1305	1171	206	NS
16:1		129	162	176	165	29.0	NS
18:0		528	581	543	490	104	NS
18:1 trans		63	147	184	173	33.2	<.01
18:1 n-9		1209	1471	1260	1225	279	NS
18:1 n-7		35	42	46	36	7.64	NS
18:2 n-6		81	78	66	64	9.21	NS
18:3 n-3		22	43	26	30	5.57	<.01
20:3 n-6		7.8	5.9	4.9	4.2	0.61	<.001
20:4 n-6		23	21	14	17	1.52	<.001
20:5 n-3 (EPA)		11	16	23	15	1.93	<.001
22:5 n-3		20	21	24	21	2.08	NS
22:6 n-3 (DHA)		2.2	2.4	4.6	4.9	.524	<.001
Total fatty acids		3529	4222	4292	3973	741	NS

1 8 animals per treatment