THE EFFECTS OF RUMINALLY-PROTECTED DIETARY LIPID ON THE LIPID COMPOSITION AND QUALITY OF BEEF MUSCLE

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Background

The potential risks to health of diets high in fats and particularly saturated fatty acids are well recognised and have led to recommendations to decrease the levels of these components of the diet (Department of Health, 1994). At the same time, increasing the consumption of n-3 polyunsaturated fatty acids (PUFA), particularly the longer-chain EPA (20:5 n-3) and DHA (22:6 n-3) has been recommended. Ruminant meats are highly saturated with a ratio of polyunsaturated to saturated fatty acids of about 0.1 or less compared with a desirable value of 0.4 – 1.0 for the whole diet. However, the ratio of linoleic acid to α-linolenic acid (n-6: n-3) in meat from forage-finished ruminants is approximately 2, well below the required dietary level of less than 4, and their muscle supplies longer-chain n-3 PUFA otherwise only found in fish and eggs (Enser *et al.*, 1996). However, increasing the PUFA content of beef has the potential to affect both the flavour of the meat and its shelf-life as a result of the susceptibility of PUFA to oxidative rancidity. By feeding cattle dietary lipids containing PUFA encapsulated in a protein matrix cross-linked with formaldehyde it is possible to raise the P:S ratio of beef tissues significantly (Scott and Ashes, 1993).

Objectives

To determine the fatty acid composition of the muscle neutral and phospholipids in beef cattle fed a protected lipid supplement (PLS) and to relate this to meat shelf-life (colour and lipid oxidation) and flavour.

Methods

Samples of *m.longissimus thoracis et lumborum* were obtained from 24 Charolais steers which had been fed on a forage: concentrate diet and one of three supplements containing equal amounts of lipid from 1. Megalac (Mega); 2. Megalac + PLS (1:1 lipid basis) and 3. PLS. The ratio of 18:2 to 18:3 in Megalac was 11:1 whereas in the PLS (Rumentek, Australia) it was 2:1. At 48h post-mortem, samples of muscle were removed and blast frozen for fatty acid analysis. Other samples were removed and conditioned for 10 days in vacuum packs at 1°C. A joint was frozen for subsequent organoleptic assessment and steaks cut and packed in a modified atmosphere. These were displayed for 10 days at 4°C under 1000 lux for 18h out of each 24h to simulate retail systems. Colour was determined daily using a Minolta Chroma Meter. Lipid oxidation was determined as thiobarbituric acid reacting substances (TBARS) (Tarladgis *et al.*, 1960) after display. After thawing steaks were cut from the frozen samples and sensory assessments made after grilling to an internal temperature of 74°C by a 10 member trained taste panel using 100mm unstructured line scales. Lipid was extracted using chloroform/methanol and the neutral and polar lipids separated by silicic acid column chromatography. Fatty acid methyl esters were prepared by alkaline hydrolysis followed by methylation with diazomethane and analysed on a CP Sil 88, 50m x 0.25mm ID column (Chrompack, UK).

Results and discussion

Feeding protected lipid containing 18:2 n-6 and 18:3 n-3 increased the percentage of these fatty acids in both the neutral lipids and phospholipids of *m.longissimus* (Table 1), but doubling the intake of protected lipid had little effect in the phospholipid fractions compared with the neutral lipids. These increases occurred mainly at the expense of oleic acid in the phospholipids and palmitic and stearic acids in the neutral lipids. Of the phospholipid long-chain PUFA, only 22:5 n-3 was decreased significantly as the ratio of 18:2 n-6/18:3 n-3 increased in response to the protected lipid. Despite these changes in fatty acid composition, effects on flavour and acceptability were small (Table 2). There was a tendency towards different flavour scores in PLS (eg. abnormal, fatty/greasy) but these effects were not significant. Susceptibility to lipid peroxidation (TBARS) and colour deterioration increased with the increases in muscle content of 18:2 and 18:3 n-3 (Fig 1, 2). However, the effects were relatively small, with colour acceptability (saturation >18) decreased by 0.5 and by 1.5 days for Mega + PLS and PLS respectively compared with Mega alone.

Conclusions

Significant improvements in the P:S ratio and PUFA content of beef muscle produced by feeding animals protected lipid can be achieved with only minor changes in shelf-life and eating quality

References

Department of Health (1994). Nutritional aspects of cardiovascular. Report on health and social subjects No. 46, HMSO, London.

Enser, M., Hallett, K., Hewitt, B., Fursey, G.A.J. and Wood, J.D. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. Meat Science, 42, 443-456.

Scott, T.W. and Ashes, J.R. (1993). Dietary lipids for ruminants, protection, utilization and effects on remodelling of skeletal muscle phospholipids. Australian Journal of Agricultural Research, 44, 495-508.

Tarladgis, B.G., Watts, B.M. and Younathan, M.T. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of the American Oil Chemists Society, 37, 44-48.

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Table 1. Fatty acid composition (% by weight) of *m.longissimus* phospholipids and neutral lipids from steers fed Mega, Mega plus PLS or PLS

Diet	Concentrate type					Concentrate type				
Fatty acid	Mega	Mega + PLS	PLS	sed	sig	Mega	Mega + PLS	PLS	sed	sig
	Phospholipid					Neutral lipid				
14:0 myristic	0.4	0.3	0.2	0.06	*	3.4	2.9	3.0	0.30	NS
16:0 palmitic	15.9	15.0	13.8	0.50	***	29.7	27.1	26.5	0.87	**
16:1 cis	1.7	1.1	1.0	0.12	***	4.5	4.4	4.2	0.27	NS
18:0 stearic	11.4	11.9	12.2	0.29	*	15.2	13.5	14.6	0.64	*
18:1 n-9 oleic	20.6	11.3	7.1	1.29	***	39.4	40.9	38.0	0.97	*
18:1 n-11	2.4	2.2	2.1	0.11	NS	0.5	0.8	1.0	0.16	**
18:2 n-6	15.0	27.5	31.7	1.34	***	1.2	3.2	4.7	0.37	***
18:3 n-3	2.3	3.3	3.1	0.17	***	0.5	1.3	1.9	0.13	***
CLA[1]	0.2	0.2	0.2	0.02	NS	0.5	0.5	0.5	0.07	NS
20:3 n-6	2.0	2.0	1.7	0.13	NS	Less than 0.1%				
20:4 n-6	6.4	6.3	6.6	0.52	NS	0.1	0.1	0.2	0.04	NS
20:5 n-3	2.2	2.0	2.0	0.20	NS	Less than 0.1%				
22:5 n-3	3.8	3.3	3.0	0.18	***	Less than 0.1%				
22:6 n-3	0.5	0.4	0.3	0.04	NS	Less than 0.1%				

[1] 9-cis, 11-trans actadecadienoic acid

Table 2. Influence of diet on the eating quality of grilled sirloin steaks.

Attributes	Concentrate type				
	Mega	Mega+PLS	PLS	sed	sig.
Toughness	56.8	60.5	56.6	3.36	ns
Juiciness	47.9	45.0	47.6	2.79	ns
Beef flavour	35.4	36.9	33.4	2.51	ns
Abnormal	11.4^{ab}	7.9^{a}	15.4^{b}	2.12	**
Fatty/Greasy	17.1^{a}	22.3^{b}	20.1^{ab}	1.77	*
Bloody	7.7	5.6	5.6	1.70	ns
Livery	5.6	5.2	4.2	1.39	ns
Metallic	6.4	4.6	6.9	1.51	ns
Bitter	3.8	5.5	5.9	1.56	ns
Sweet	6.8	6.7	5.8	1.41	ns
Rancid	3.4	4.1	3.9	1.21	ns
Fishy	2.3	1.6	2.9	0.70	ns
Acidic	6.0	6.1	7.1	1.45	ns
Cardboard	7.1	9.4	6.8	1.59	ns
Vegetable	6.3	5.3	8.0	1.54	ns
Overall liking	25.8	25.1	23.3	2.83	ns

[ab] Figures with the same superscript do not differ significantly

Fig 1. Effect of diet on colour shelf-life (± sem) of beef loin steaks displayed in MAP

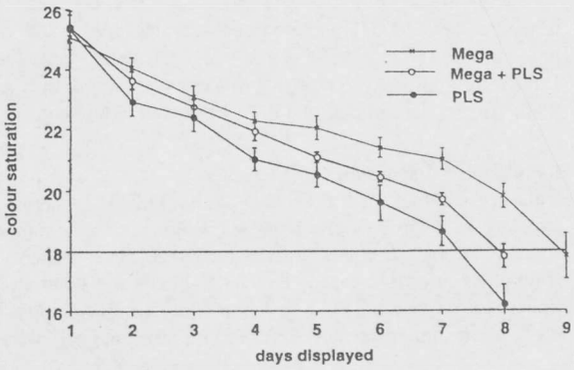

Fig 2. Effect of diet on mean TBARS (±sem) of beef loin steaks after 10d display in MAP