EFFECTS OF PRODUCTION SYSTEMS ON THE FATTY ACIDS AND FLAVOUR OF LAMB FROM SIX EUROPEAN COUNTRIES

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Background

Meat flavour depends upon components present in the tissue of the live animal and those produced during cooking as a result of the Maillard reaction, the Strecker degradation, lipid peroxidation and their interactions. Production systems can affect both, particularly via the feed. Fatty acids are essential to the development of cooked meat flavour (Mottram and Edwards 1983) and differences in flavour of meat from different production systems, eg grass versus grain finished, has been attributed in part to the relative levels of linolenic acid (18:3 n-3) and linoleic acid (18:2 n-6) and the longer-chain polyunsaturated fatty acids (PUFA) of each series (Purchas *et al*, 1979; Larick and Turner, 1990). Medium chain-length branched fatty acids are also important components of lamb fat odour (Wong *et al*, 1975; Young *et al*, 1997). Other compounds such as dietary derived phenols (Ha and Lindsay, 1991) and metabolic products such as skatole (Young *et al*, 1997) also make major contributions to flavour, particularly of forage fed lamb. However, the role of diet and production system in lamb flavour still remains unclear.

Objective

To determine the fatty acid composition of muscle and adipose tissue of lamb from two production systems in six European countries and relate it to flavour assessed organoleptically.

Methods

One hundred and twenty lambs of each of two production systems (Table 1) were slaughtered in their country of origin under EC regulations and 20 samples of the loin from each type were vacuum packed, frozen and delivered to GB. The meat was cooked to an internal temperature of 75°C and the *longissimus lumborum* assessed by a trained panel of 10 assessors for agreed flavour attributes using unstructured line scales of 0 (low) to 100 (high). Lipids were extracted with chloroform: methanol from adjacent *longissimus* and separated into the neutral and phospholipid fraction using silicic acid mini columns. Lipid was extracted from the complete thickness of subcutaneous adipose tissue over the *longissimus* muscle with chloroform in the presence of anhydrous sodium sulphate. Fatty acids were prepared from the lipids by alkaline hydrolysis after adding 21:0 methyl ester as internal standard. Methyl esters were synthesized using diazomethane and were analysed by gas-liquid chromatography on a CPSil88, 50m x 0.25mm column and quantified from the internal standard.

Results and discussion

The fatty acid compositions of the *longissimus* phospholipids and subcutaneous adipose tissue varied according to production system. In adipose tissue, 14:0 and 16:0 were high in milk fed lambs (ES2, GRE1) and 18:0 was low. Trans 18:1 was highest in ES1 fed concentrates and straw and FRA2 fed concentrates. Concentrates also produced the highest levels of 18:2 (ES1, GRE2, FRA2, ITA2). Pasture or hay gave high 18:3 and CLA whereas branched-chain fatty acids were high in GB2 and ITA but not in other forage fed lambs. In the muscle phospholipids, the percentage of 16:0 and 18:0 varied little between lamb types. As in adipose tissue, trans 18:1 was highest in ES1 and FRA2. Phospholipid 18:1 n-9 varied much more than in adipose tissue, being lowest in ES1 and GRE2 fed concentrates and highest in GB2 fed pasture. 18:2 and 20:4 were highest in concentrate fed lambs, intermediate in those fed milk and lowest in pasture fed lambs except for ITA1. Pasture fed lambs had the highest percentages of 18:3, 20:5 and 22:5 but 22:6 was highest in milk fed lambs despite their low 18:3 level.

Forage fed lamb had high scores for lamb flavour (Table 4) although GB taste panel for which they are the norm. Despite this GB1 and ITA1 fed grass scored poorly and GRE2 fed concentrates and hay scored high. The livery flavour was highest for pasture-fed lamb and lowest for those on milk, matching the relative levels of 18:3 and 18:2. Rancid scores were high for pasture-fed FRA1 lamb and milk-fed ES2 and GRE1 whereas they were low for pasture fed ICE1, ICE2 and GB1. Fatty, metallic and soapy were all high for milk fed lamb and lowest for those grazing pasture. Beefy also was higher in grass fed lamb whereas bitter and fishy showed no clear relationship to diet.

Conclusion

Although there were clear relationships between diet and fatty acid composition of adipose tissue and muscle phospholipids, relationships with flavour descriptors were less clear. The usual relationships between 18:3 and lamb flavour (Sanudo *et al*., 2000) and high n-3 PUFA and rancid and metallic can be modified by other factors.

References

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Table 1. Description of 12 lamb types used to study sensory responses

Lamb type		Breed	Sex	Age (wk)	Main feeds consumed
1. GB	GB1	Suffolk x Mule	Castrated male	18	Lowland pasture and milk to slaughter
2. GB	GB2	Welsh Mountain	Entire male	32	Natural upland flora and milk
3. Spain	ES1	Rasa Aragonesa	Entire male	11	'Ternasco de Aragon': milk to 8 weeks, concentrates and straw
4. Spain	ES2	Churra	Entire male	<5	'Lechazo de Castilla y Leon': milk to slaughter
5. France	FRA1	Texel, Ile-de-France, Charolais	Female	28	'Agneau d'herbe': pasture
6. France	FRA2	Lacaune	Female	14	'Agneau de bergerie': concentrates
7. Greece	GRE1	Karagouniko	Entire male	7	Milk to slaughter
8. Greece	GRE2	Karagouniko	Entire male	18	Concentrates and lucerne hay
9. Iceland	ICE1	Icelandic	Entire male	18	Natural pasture and milk to slaughter
10. Iceland	ICE2	Icelandic	Female	18	As above
11. Italy	ITA1	Bergamasca	Castrated male	50	Transhumance flocks: upland flora and crop residues
12. Italy	ITA2	Appenninica	Entire male	10	Milk at night, concentrates during day

Table 2. Fatty acid composition of the *longissimus lumborum* phospholipids (% by weight)

Lamb type		16:0	18:0	18:1 trans	18:1 n-9	18:2 n-6	18:3 n-3	20:4 n-6	20:5 n-3	22:5 n-3	22:6 n-3
GB	1	13.6	12.0	1.4	23.4	10.4	5.6	5.0	4.4	3.8	1.5
GB	2	12.7	12.2	1.3	25.2	9.7	5.6	4.9	4.2	3.3	1.5
ES	1	12.3	11.0	3.4	15.4	22.4	1.0	9.7	1.4	2.2	0.9
ES	2	12.5	18.2	0.8	22.1	16.3	1.6	9.2	2.5	3.2	2.6
FRA	1	12.7	11.6	1.2	21.1	14.3	4.6	6.4	3.7	3.5	1.1
FRA	2	13.5	10.7	2.3	21.1	20.3	1.4	8.0	1.5	2.2	0.8
GRE	1	11.8	12.0	0.4	18.0	18.8	1.3	13.1	2.3	3.3	2.1
GRE	2	13.0	11.3	1.3	15.7	21.1	1.4	12.6	1.3	2.5	1.1
ICE	1	12.2	12.0	0.9	20.5	14.7	6.2	4.9	4.9	4.0	1.7
ICE	2	12.2	11.9	0.7	20.6	15.3	6.5	4.7	4.9	3.7	1.6
ITA	1	11.4	12.2	0.6	18.6	18.7	4.5	7.4	3.1	3.3	1.2
ITA	2	12.4	11.0	1.2	17.1	21.1	2.3	9.3	3.4	3.3	1.7
Sed		0.26	0.20	0.14	0.84	0.61	0.18	0.31	0.17	0.12	0.11
P		<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Table 3. Fatty acid composition of lamb subcutaneous (loin) adipose tissue (% by weight)

Lamb type:	GB1	GB2	ES1	ES2	FRA1	FRA2	GRE1	GRE2	ICE1	ICE2	ITA1	ITA2	sed	P
14:0	8.6	4.0	4.7	10.7	4.5	3.7	10.8	7.2	5.9	5.4	2.6	8.0	0.46	<.001
16:0	23.1	21.0	23.3	31.7	22.3	22.9	28.2	26.3	24.4	23.9	21.4	24.2	0.67	<.001
18:0	18.2	19.2	11.7	12.9	22.7	12.3	10.1	12.7	21.6	21.7	22.2	12.4	0.84	<.001
18:1 trans	7.1	6.9	12.5	1.8	5.8	8.3	1.7	3.0	4.5	4.0	4.3	4.0	0.42	<.001
18:1 n-9	26.0	29.7	27.8	29.1	28.5	33.8	33.0	33.5	27.8	30.0	30.5	34.4	0.90	<.001
18:2 n-6	1.0	0.9	4.8	1.9	1.6	3.2	2.6	3.0	1.5	1.5	2.0	3.3	0.16	<.001
18:3 n-3	0.9	0.9	0.4	0.4	1.1	0.5	0.5	0.6	1.5	1.5	1.3	0.9	0.08	<.001
CLA	2.3	1.9	0.4	0.6	1.3	0.6	0.7	0.7	1.1	1.1	0.9	1.2	0.09	<.001
Branched	2.3	5.2	3.3	1.8	2.7	4.1	1.9	2.5	2.4	1.9	3.6	1.9	0.44	<.001

Table 4. Influence of lamb type on the flavour attributes of grilled lamb loin

	GB1	GB2	ES1	ES2	FRA1	FRA2	GRE1	GRE2	ICE1	ICE2	ITA1	ITA2	sed	P
Flavour														
Sheepmeat	13.0	18.0	13.9	15.1	16.7	14.9	12.2	15.5	17.0	15.1	12.8	14.6	1.489	<.001
Livery	14.9	20.7	12.9	8.3	16.5	14.7	10.5	10.9	23.3	22.2	12.2	9.5	1.610	<.001
Rancid	19.5	15.1	18.8	21.0	25.3	17.9	20.2	17.4	14.9	10.3	15.7	18.6	1.743	<.001
Fatty	24.5	23.8	26.3	31.8	22.7	25.9	30.9	30.3	20.4	20.1	25.1	29.0	1.354	<.001
Dairy	7.8	7.6	7.3	7.4	8.5	8.1	7.7	9.3	8.0	8.6	10.0	6.9	1.438	ns
Metallic	9.0	6.6	12.7	10.7	9.7	9.1	9.7	8.0	8.1	7.5	8.0	10.1	1.400	<.001
Bitter	14.6	14.3	14.1	13.4	19.3	14.6	15.2	13.8	15.7	13.4	12.5	14.5	1.718	<.05
Soapy	6.4	8.8	18.3	17.5	12.1	11.2	17.4	12.4	6.0	5.2	6.7	12.4	1.688	<.001
Beefy	10.4	10.3	7.3	6.8	8.0	9.4	8.9	6.4	9.3	10.8	15.3	9.7	1.459	<.001
Fishy	2.0	2.8	2.9	1.8	2.0	2.2	2.9	2.4	1.3	1.3	1.8	2.6	0.656	ns