VOLATILE COMPOSITION OF BEEF AS INFLUENCED BY FORAGE AND CONCENTRATE- BASED DIETS

K. Galvin[1], P.A. Morrissey[1], J.P. Kerry[1], D.J. Buckley[1], and A.P. Moloney[2]

[1]Department of Food Science and Technology, University College, Cork and [2]Teagasc, Grange Research Centre, Dunsany, Co. Meath, Ireland

Background
Consumers regard flavour as an important factor in the assessment of the eating quality of beef (*Cowan et al., 1999*). One of the main factors influencing beef flavour is diet. Studies examining the effect of diet on beef flavour have mainly focused on differences between forage- and concentrate-based diets (*Muir et al., 1998*). However, few studies have examined the effects of different types of concentrates and forages on flavour. Any change in diet can potentially have an impact on flavour and, therefore, a better understanding of the relationship between diet and flavour is important. The basis for flavour development in meat is the formation of volatile aroma compounds during the cooking process, arising from the reaction of precursors derived from the lipid and non-lipid components of meat. Therefore, the changes in volatile composition in response to diet play a key part in understanding diet-induced flavour changes in meat.

Objective
The aim of this study was to examine the effect of dietary composition (i.e., grass, silage and concentrates) on the volatile composition of beef.

Methods
Friesian steers were randomly divided into 5 groups and fed diets consisting predominantly of extensively fermented grass silage (Group 1), restricted-fermentation grass silage (Group 2), starch-based concentrate (rolled barley) (Group 3), non-starch-based concentrate (unmolassed beet pulp) (Group 4) or perennial ryegrass (Group 5). All diets were adjusted so that growth rate was similar for all five groups. All steers were fed the experimental diets for approximately 20 weeks prior to slaughter. Steaks were cut from the striploin and cooked in an electric oven (170°C) to an internal temperature of 70°C. Cooked meat was trimmed of visible fat and minced twice using a kitchen mincer fitted with a plate with 5mm diam. holes. Five grammes of meat were immediately placed in a 100ml pear shaped flask with 7ml of water and 1µl of internal standard (nonane). The sample was purged with nitrogen for 5 minutes at 37°C. Volatiles were trapped on Tenax TA (60/80 mesh) in glass tubes (177mm x 6mm o.d.). One steak from each group was analysed 3 times. Volatiles were desorbed in a Tekmar 3000 purge and trap concentrator (225°C for 6 minutes), coupled to a Varian Star 3400 CX GC and cryofocused at -70°C onto a BPX 5 capillary column (60m x 0.32mm i.d., film thickness 1.0µm; SGE (UK) Ltd.). The GC was interfaced with a Varian Saturn 3 mass spectrometer. Data were collected using the Saturn version 5.2 software package. Identification of volatile components was attempted by background subtraction and computer searching of observed mass spectra against those in the NIST92 Mass Spectal data base, or in previously published literature. Compounds were semi-quantified using ion specific to the compound being analysed, and results were reported as peak areas. Data were subjected to analysis of variance (ANOVA). Where significant differences were observed, means were compared by the method of least significant difference. Principal component analysis (PCA) was also carried out.

Results and discussion
Twenty one compounds were identified and quantified in beef steaks (Table 1). ANOVA showed a significant ($P<0.05$) effect of diet on 15 compounds. However, these differences between individual compounds did not clearly distinguish dietary treatments from each other. In order to investigate the overall effect of diet on volatile composition and the relationships between groups, PCA was carried out using all 21 compounds. Significant differences were observed between groups on principal components (PC) 1, 2 and 3 ($p = 0.000$). These 3 components explained 70% of the total variance. PC1 distinguished groups 1, 2 and 5 (silage and grass-based) from groups 3 and 4 (concentrate-based) (figure 1a). Most compounds were positively loaded on PC1, indicating that the forage-based diet tended to release more of all volatiles compared to concentrate-based groups, and this accounted for the greatest difference between groups. This is supported by previous observations of higher levels of lipid-drived volatiles in subcutaneous fat from forage-fed steers compared to concentrate-fed animals (*Larick et al., 1987*). PC2 and 3 revealed smaller differences between groups. PC2 distinguished groups 2 and 5 from group 1. Groups 2 and 5 were characterised by aldehydes and ketones, while 1 was distinguished by non-lipid components, including sulphur compounds. Concentrate-based groups (3 and 4) were distinguished from each other on PC 2 (Figure 1b), while groups 2 and 5 (silage and grass-based) were separated from each other on PC3. Differences between these groups were more subtle. Differences appeared to be due to the balance of individual compounds rather than differences between classes of compounds.

Conclusions
The volatile composition of beef was influenced by diet. Greatest differences were observed between forage and concentrate-based diets, with forage-based diets tending to result in more volatiles being released. However, differences were also observed between different types of forage and grain-based diets, indicating a dietary effect on overall volatile composition. These changes could result in flavour differences between the dietary treatments.

Acknowledgements
This research was part funded by grant aid under the Food Sub-Programme of the Operational Programme for Industrial Development which is administered by the Department of Agriculture, Food and Forestry, Dublin, Ireland, and supported by national and European Union funds.

References
Cowan, C., Mannion, M., Langan, J. & Keane, J.B. (1999). *Consumer Perceptions of Meat Quality*, research report no. 2 Teagasc, Dublin.
Larick, D.K., Hedrick, H.B., Bailey, M.E., Williams, J.E., Hancock, G.B. & Morrow, R.E. (1987). Flavour constituents of beef influenced by forage- and grain-feeding. *Journal of Food Science*, **52**, 245-251.
Muir, P.D., Deaker, J.M. & Bown, M.D. (1998). Effects of forage- and grain-based feeding systems on beef quality: A review. *New Zealand Journal of Agricultural Research*, **41**, 623-635.

Table 1. Effect of dietary treatment on volatile compounds in beef steaks

Compound	Grass silage		Concentrates		Grass
	Extensively fermented	Restricted fermentation	Starch-based	Non starch-based	
Propanal	313^{a}	642^{a}	134^{a}	80^{a}	532^{a}
Butanal	9^{a}	23^{a}	60^{a}	3^{a}	15^{a}
Pentanal	672^{a}	2390^{b}	484^{a}	353^{a}	915^{a}
Hexanal	5656^{a}	25379^{b}	5495^{a}	2962^{a}	11595^{a}
Heptanal	96^{ac}	312^{b}	141^{ac}	62^{a}	215^{cb}
Octanal	15^{a}	23^{a}	19^{a}	21^{a}	15^{a}
Nonanal	18^{a}	18^{a}	26^{a}	21^{a}	16^{a}
Benzaldehyde	209^{a}	155^{a}	231^{a}	489^{b}	192^{a}
3-Methylbutanal	37^{ad}	39^{a}	12^{bc}	29^{abe}	17^{ce}
2-Butanone	36^{a}	29^{a}	10^{b}	10^{b}	9^{b}
2-Heptanone	20^{a}	32^{a}	485^{b}	13^{a}	52^{a}
2,3-Pentanedione	40^{a}	697^{b}	43^{a}	42^{a}	65^{a}
2,3-Butanedione	286^{a}	509^{a}	324^{a}	282^{a}	361^{a}
1-Penten-3-ol	177^{ac}	500^{bc}	114^{ac}	94^{a}	363^{ac}
2-Methylfuran	6^{a}	5^{a}	4^{a}	6^{a}	5^{a}
Dimethyl disulphide	47^{a}	10^{b}	10^{b}	4^{b}	27^{c}
Carbon disulphide	368^{a}	9^{b}	4^{b}	2^{b}	12^{b}
Toluene	239^{a}	517^{b}	152^{c}	416^{b}	454^{b}
Limonene	40^{a}	35^{a}	14^{b}	9^{b}	17^{b}
Styrene	19^{a}	16^{a}	12^{c}	11^{b}	13^{b}
Xylene	28^{a}	30^{a}	5^{b}	4^{b}	9^{b}

Values are means of five analyses.
a-d Within each row, means bearing different superscripts are significantly different ($p<0.05$).

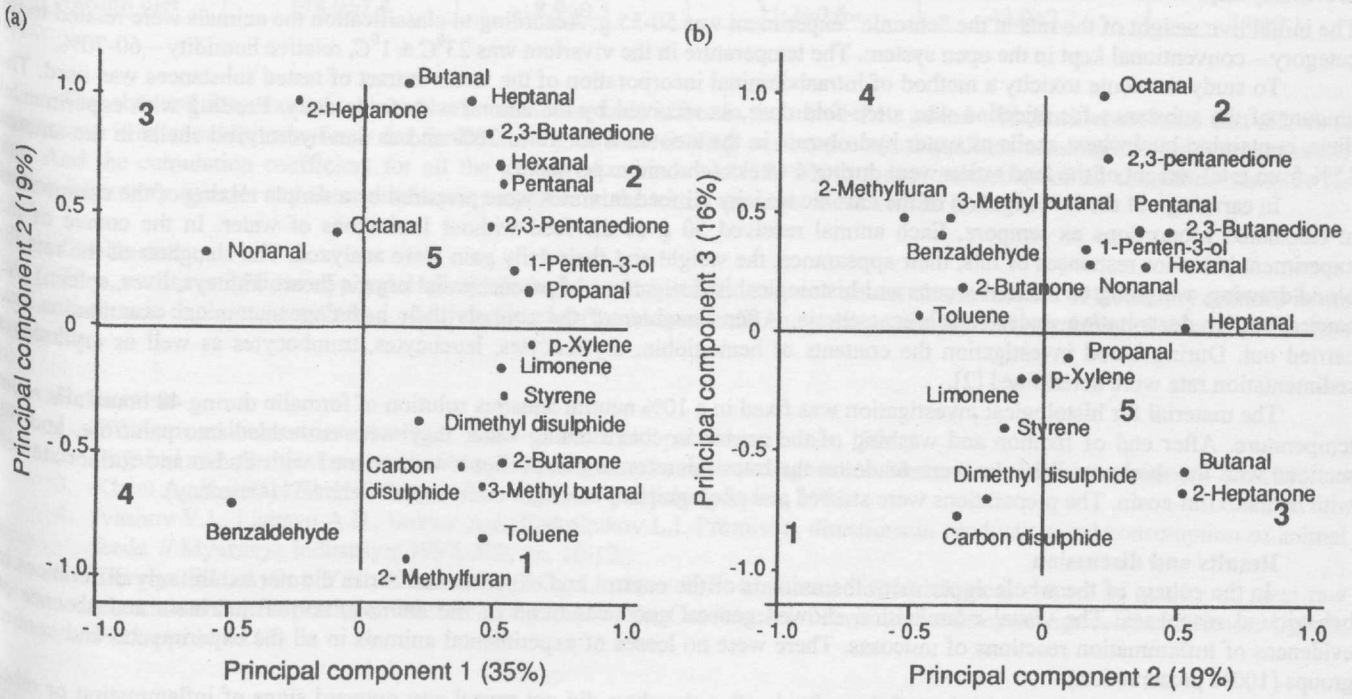

Figure 1. PCA scores for groups fed extensively fermented silage (1), restricted-fermentation silage (2), starch-based concentrate (3), non starch-based concentrate (4) and grass (5), and loadings for volatile compounds on PC's (a) 1and 2 and (b) 2 and 3.