VOLATILE COMPOUNDS AND "GRASSY" FLAVOUR OF LAMB AND BEEF RELATED TO FEEDING AND STORAGE

M.E. Bailey*, J. Suzuki, H.G. Joseph, C.V. Ross and D.H. Keisler, Departments of Food Science and Nutrition and Animal Science, University of Missouri-Columbia; and R.W. Purchas, Department of Animal Science, Massey University, Palmerston North, New Zealand.

INTRODUCTION

The objective of this research was to establish the relationship between quality and quantity of volatile organic compounds in lamb and beef fat, and intensity of "grassy" flavour of meat from animals finished on various forages and corn grain.

A trained, quantitative sensory panel could distinguish between the "grassy" flavour of meat from lamb and beef finished on forage from that of animals finished on corn, but had difficulty differentiating samples from animals finished on various forages.

Volatiles from the fat of animals finished on grain were lower in concentration than those of animals finished on forage and there were significant ($P < .05$ or greater) correlations between the concentrations of volatile compounds and "grassy" flavour.

There were observable and reproducible differences in lamb and beef volatiles due to their finishing diet and essentially all samples were correctly characterized into groups according to their finishing diets from quantitative data of the organic volatiles in fat.

EXPERIMENTAL METHODS

Lamb samples.

Southdown x Romney lambs were grown at Massey University, New Zealand on pastures of white clover (*Trifolium repens*), lucerne (*Medicago sativa*), lotus (*Lotus corniculatus*) and rye grass (*Lorium perenne*). Loins from the left sides of these animals were shipped by refrigerated boat and truck to Missouri, where they were compared with loin samples from lambs finished on high concentrate diets (corn, cottonseed hulls, oats and soybean meal) and on corn grain supplement (0.91 kg/day) while grazing on fescue or on orchardgrass pasture with no grain.

Samples were analyzed by a sensory panel for "lamby-grassy" flavour and for flavour volatiles by gas liquid chromatography/mass spectrometry.

This study was repeated a second year.

Beef samples.

Angus or Angus/Hereford steers were grown at Massey University, New Zealand on predominantly white clover or perennial rye grass, and strip loins from the right sides were frozen and shipped to Missouri by refrigerated boat and truck, where they were compared with samples from loins of Hereford steers finished on high concentrate diet (corn, corn silage and soybean meal). Beef samples were analyzed for "grassy" flavour by sensory analysis and for flavour volatiles by GLC/MS. These procedures were repeated for three years.

Processing of Samples.

Subcutaneous fat and the *Longissimus dorsi* muscle were separated from each lamb and beef loin, vacuum packaged in Cryovac, frozen and stored at -20°C. Fat for chemical analysis was melted at 150°C for 30 min, filtered through fritted glass and stored at -20°C in teflon-capped test tubes after flushing with nitrogen gas.

Sensory Analysis.

Ten samples from each test group of lambs were analyzed by six sensory panel members trained to quantify "lamby-grassy" flavour. They tested ground lamb formulated to contain 10% fat by a method similar to that of Winger and Pope (1981).

Six beef samples were analyzed by seven panel members for "grassy" flavour. The samples were ground beef containing 20% fat.

Gas Liquid Chromatography/Mass Spectrometry Analysis of Fat from Lamb and Beef Samples.

The direct-sampling method of Suzuki and Bailey (1985) was used to analyze volatile flavour compounds in six samples from each experimental class of lambs and beef.

Table 1. Significant simple correlation coefficients between quantities of flavor volatiles in ovine and bovine fat and sensory scores for flavor intensity.

Compound	Correlation Coefficient	
	Lambs[a]	Steers[b]
Pentanal	0.462[c]	-----
Hexanal	0.307[d]	-----
Heptanal	0.608[c]	0.460[c]
2,4-Hexadienal	0.393[c]	-----
2,3-Octanedione	0.481[c]	0.518[c]
α-Pinene	0.625[c]	-----
2,4-Heptadienal	0.512[c]	0.366[d]
Octanal	0.506[c]	-----
2,3-Nonanedione	0.460[c]	-----
3-Hydroxy-2-octanone	0.435[c]	0.339[e]
Nonanal	0.528[c]	0.533[c]
2-Nonenal	0.528[c]	0.423[d]
Dodecane	0.458[c]	-----
2-Decenal	0.342[d]	0.433[c]
2-Undecanone	0.431[c]	-----
2,4-Decadienal	-----	0.287[e]
2-Tridecanone	0.392[c]	0.371[d]
2-Undecenal	0.501[c]	-----
δ-Dodecalactone	0.367[d]	-----
Phyt-1-ene	0.374[d]	0.510[d]
Octadecane	0.432[c]	0.331[e]
Phytane	0.489[c]	0.343[e]
Neophytadiene	0.380[c]	0.408[e]
Phyt-2-ene	0.657[c]	0.462[c]
Phytadiene	0.339[d]	-----
Dihydrophytol	0.299[d]	-----
Phytol	0.469[c]	0.343[c]

[a] N=72
[b] N=48
[c] (P<0.001)
[d] (P<0.01)
[e] (P<0.05)

Forty-eight volatile compounds were quantitatively analyzed in lambs. Data were analyzed for separate years and for both years combined using analyses of variance for a fixed model, two-way design (Cochran and Cox 1957) with year and treatment. Stepwise discriminant analysis was applied to GLC profiles of volatile compounds to clarify differences among treatments (SAS 1982). Canonical variables were calculated by using 20 peaks selected by stepwise discriminant analysis. Two-dimensional canonical plots were obtained from these analyses.

Similar procedures were used for beef.

RESULTS

Lambs.

The results of Duncan's multiple range test revealed that lambs fed on high concentrate diet (corn) and lambs supplemented with 0.91 kg corn per day while grazing on fescue were milder in "lamby-grassy" flavour than lambs grazing on forage. Among the treatments, lotus-fed lambs had lower scores for flavour intensity, but the difference was not statistically significantly ($P<.05$) different from lucerne, but was significantly ($P<.05$) lower than animals on rye grass or clover. There was no significant difference in flavour of meat from animals finished on the latter two, except that scores for animals finished on rye grass were lower than those on clover.

Similar results were found the second year when radish tops were found to produce milder "lamby-grassy" flavored meat compared to the other forages, and the order of "grassy" flavour changed to lucerne lotus clover rye grass.

Fifty-five volatile compounds were identifiable in the fat of lambs. Most of these were discussed in a previous paper (Suzuki and Bailey 1985).

Forty-eight compounds were quantitated by this method. The major groups of compounds were aldehydes, ketones, hydrocarbons, diterpenes and acids, and there were high correlations between many of these compounds and intensity of lamb flavour (Table 1). The outstanding difference between volatiles from fat of lambs finished on forage compared to those of lambs finished on corn was the high amounts of 2,3-octanedione, 3-hydroxy-2-octanone and diterpenoids found in the former samples.

A highly correlated prediction equation with eight GLC peaks was derived by using multiple regression analysis to predict sensory score ($r=0.875$; $r^2=0.765$). The most predictive compounds for sensory scores for lamb were heptanal and phyt-2-ene.

The results of stepwise discriminant analysis revealed that there were reproducible and observable differences in GLC profiles according to the finishing diets of the animals. Canonical discriminant analyses were performed on GLC profiles to plot samples on a two-dimensional scattergram. The group formation on the two canonical variables indicated that the quality difference and flavour characteristics of the samples due to the finishing diets can be determined without exception by differences in their GLC profiles.

In a direct comparison of fat samples from lambs finished on grain compared to those from lambs finished on orchardgrass, loin samples were stored at -15°C for 50 days and at 4°C for 7 days, and compared with control samples analyzed at zero storage time.

2,3-Octanedione and 2-hydroxy-2-octanone in the grain-finished samples did not change in concentration during storage at -15°C for 50 days. They were three-fold more concentrated in the orchardgrass-finished samples and increased significantly (P.05) in quantity during storage. Diterpenes (i.e. phyt-1-ene, neophytadiene and phyt-2-ene) decreased in concentration during storage at -15C. The relative degree of "grassy" flavour did not change in either type of sample during storage.

The diterpenes also decreased in concentration in grain- and grass-finished samples during storage at 4°C for seven days. Samples from animals finished on grass were from 3- to 6-fold more concentrated in these constituents as those from animals finished on grain and account for a large percentage of the variation in "grassy" flavour of lamb.

Beef.

Comparisons of "grassy" flavored beef with volatile compounds from fat were similar to data discussed for lamb and that previously published for beef finished on other forages (Larick et al. 1987). Beef from animals finished on corn grain had less "grassy" flavour than that of animals finished on forage.

Volatile compounds significantly related to "grassy" flavour of beef are listed in Table 1. Quantities of these compounds were used to separate animals into the different dietary treatment groups.

DISCUSSION

The above results confirm previous work where subjective data revealed strong or undesirable flavour in meat from lambs finished on forage (Cramer et al. 1967; Shorland et al. 1970; Park et al. 1972), and the topic has been thoroughly reviewed by Field et al. (1983). Similar data have been reported for beef (Purchas and Davies 1974; Bowling et al. 1977; Reagan et al. 1977; Davis 1977; Melton et al. 1982). Sensory analyses were used to judge flavour in previous studies and, more recently, both subjective and objective studies have been used to evaluate flavour of beef finished on forage and grain (Larick et al. 1987).

Concentrations of volatile compounds in animal fat correlate very significantly with subjective "grassy" flavour, and these results are a continuation of those already published from these laboratories (Suzuki and Bailey 1985; Larick et al. 1987) and reveal the association of oxidation products from unsaturated fatty acids and diterpenoids and the "grassy" flavour of meat from animals finished on forage. The term "grassy" is descriptive of the bitter, horse-sweaty, cow-breathy, metallic flavour judged to characterize meat from animals finished on forage.

CONCLUSIONS

Diet can alter lamb and beef flavour other than that contributed by sex, specie or age, and could be used to improve acceptance of this product in some countries.

The characteristic "grassy" flavour can be qualitated by sensory panels and by quantitatively measuring selected volatiles from animal fat.

One should be able to predict potential flavour of animal tissue from the analysis of small biopsy samples during growth and development of lambs and beef cattle.

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