RELATIONSHIP BETWEEN VOLATILE COMPOUNDS IN FAT FROM FORAGE AND GRAIN-FED BEEF AND SENSORY CHARACTERISTICS OF STEAKS AND ROASTS

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INTRODUCTION

The flavor of beef is influenced by numerous factors (Patterson, 1975). Pre-slaughter factors which have been investigated include breed, age, sex, feed and fatness, while post-slaughter factors include aging, microbial contamination, storage and cooking procedures. There is considerable evidence that volatiles from lean beef, pork and lamb contribute an identical meaty flavor and that species flavor differences can be attributed to volatiles in fat (Hornstein and Crowe, 1964; Wasserman and Spinelli, 1972). Watanabe and Sato (1971) have identified a number of volatile compounds associated with flavor of beef fat.

The traditional method in the United States of producing beef for use as steaks and roasts consists of a final finishing period in dry lot using principally a grain diet. A variety of grains are used and only rarely do complaints about flavor arise which can be attributed to diet. However, pasture and forage crops are extensively used for beef production and their use will likely increase in the future due to competitive uses for feed grains. The composition of forages has been reported to cause flavor variation in lamb, often of an adverse nature (Shorland et al., 1970; Park et al., 1972 a, b). Westerling and Hedrick (1979) reported that flavor of beef from fescue pasture-fed animals was less desirable than that from grain-fed animals.

The objective of the present investigation was to identify and compare volatile compounds in the fat from fescue pasture-fed cattle and grain-fed cattle that may be associated with the flavor of cooked steaks and roasts.

MATERIALS AND METHODS

Angus X Hereford steer calves (average weight approximately 225 kg) were obtained in October and grazed on winter pastures, supplemented with hay, corn and soybean meal until mid-April. The average daily live weight gain during the wintering phase was 0.2 to 0.3 kg. After the wintering phase nine animals were assigned to each of three treatments as follows: (1) fescue pasture for six months, (2) fescue pasture for approximately 3 months followed by ad libitum corn grain while on fescue pasture for approximately 5 months and (3) fescue pasture for six months and then ad libitum corn grain and protein supplement in dry lot for approximately three months. The animals were slaughtered at the conclusion of the above described treatments. The average carcass weights and quality grades were as follows: Treatment 1, 148 kg and Standard-; Treatment 2, 280 kg and Good+; and Treatment 3,285 kg and Good+. Carcasses were aged at 3°C for 10 days. Steaks from the short loin (2.5 cm thick) and roasts from the top round (semimembranosus muscle) were used for sensory analyses. Subcutaneous adipose tissue samples were removed from the short loins and later analyzed for volatile compounds.

The loin steaks were cooked to an internal temperature of 70°C in a 177°C oven. The top round roasts were cooked to an internal temperature of 70°C in a 149°C oven. Samples of the steaks (longissimus muscle) and roasts (semimembranosus muscle) were presented to a six member sensory panel and evaluated for flavor and overall acceptability using an eight point scale (1-extremely undesirable to 8-extremely desirable).

Preparation of the adipose tissue samples from the short loins involved melting the samples at 177°C in covered pyrex beakers. The melted fat was then placed in tightly capped test tubes and held frozen until analyzed. Six hundred milligram samples of beef fat were analyzed by gas-liquid chromatography-mass spectrometry, using a direct sampling procedure (Legendre et al., 1979). The volatiles from the beef fat were removed by heating in the direct sampler for 20 minutes at 180°C followed by gas-liquid chromatography on 7% Poly MPE on Tenax GC (80-100 mesh). Detection was by a Hewlett-Packard quadropole mass spectrometer (Model No. 5930-A) interfaced to the gas-liquid chromatograph with a silicone membrane separator. The data system was a Incos/Finnigan 2300. All other procedures were the same as those described by Legendre et al. (1979).

RESULTS AND DISCUSSION

The volatile compounds identified from subcutaneous fat samples of beef produced on the three nutritional regimens are presented in Figures 1, 2 and 3 and Table 1. Molecular structural assignment of each compound was done by interpretation of the fragmentation patterns of the mass spectra. Essentially the same compounds were identified in fat from animals on all three nutritional treatments. However, major differences were observed in the total volatiles (Table 2). Fat from fescue-fed animals contained more total volatiles than did either of the treatments that received ad libitum grain diets. Whereas, fat from the animals that received grain ad libitum on fescue pasture contained slightly more total volatiles than did animals that received grain ad libitum in dry lot.

Sensory panel flavor scores of loin steaks and round roasts from the three nutritional treatments are presented in Table 3. The sensory panel evaluated the lean and not subcutaneous fat per se. However, during cookery some of the subcutaneous fat would have been translocated throughout the lean. Both steak and roast samples from the fescue-fed animals were scored less desirable ($P<.05$) than samples from either of the other two treatments. Differences observed by the sensory panel appear to be related to the differences in total volatiles, and particularly compounds numbered 23 through 36, determined by the analytical method. Compounds likely responsible for the more undesirable flavor and aroma include methyl benzaldehyde (24), napthalene (27), 2.4-decadienal (28), and octadecane (part of peak 34).

The characteristic flavor of lean samples from the fescue-fed aniamls was described as grassy, bitter and cow-like. Flavor and aroma of cooked fat was much more intense and more undesirable than that of the lean.

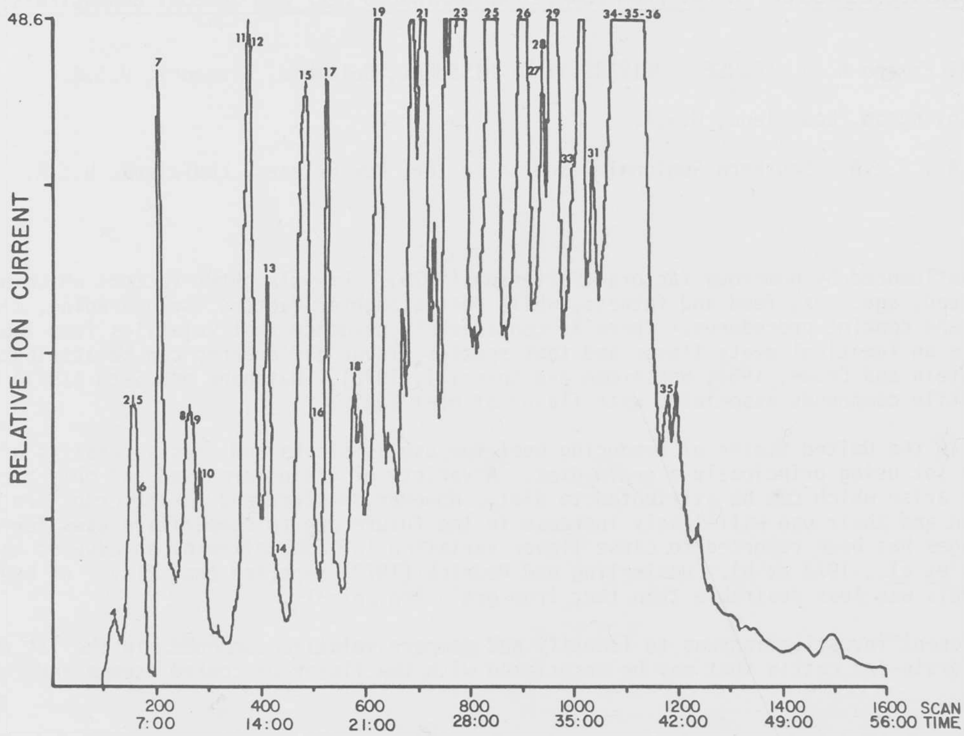

Figure 1. Volatile compounds from subcutaneous fat of fescue pasture-fed cattle. (See Table 1 for nomenclature of compounds corresponding to numbers on peaks).

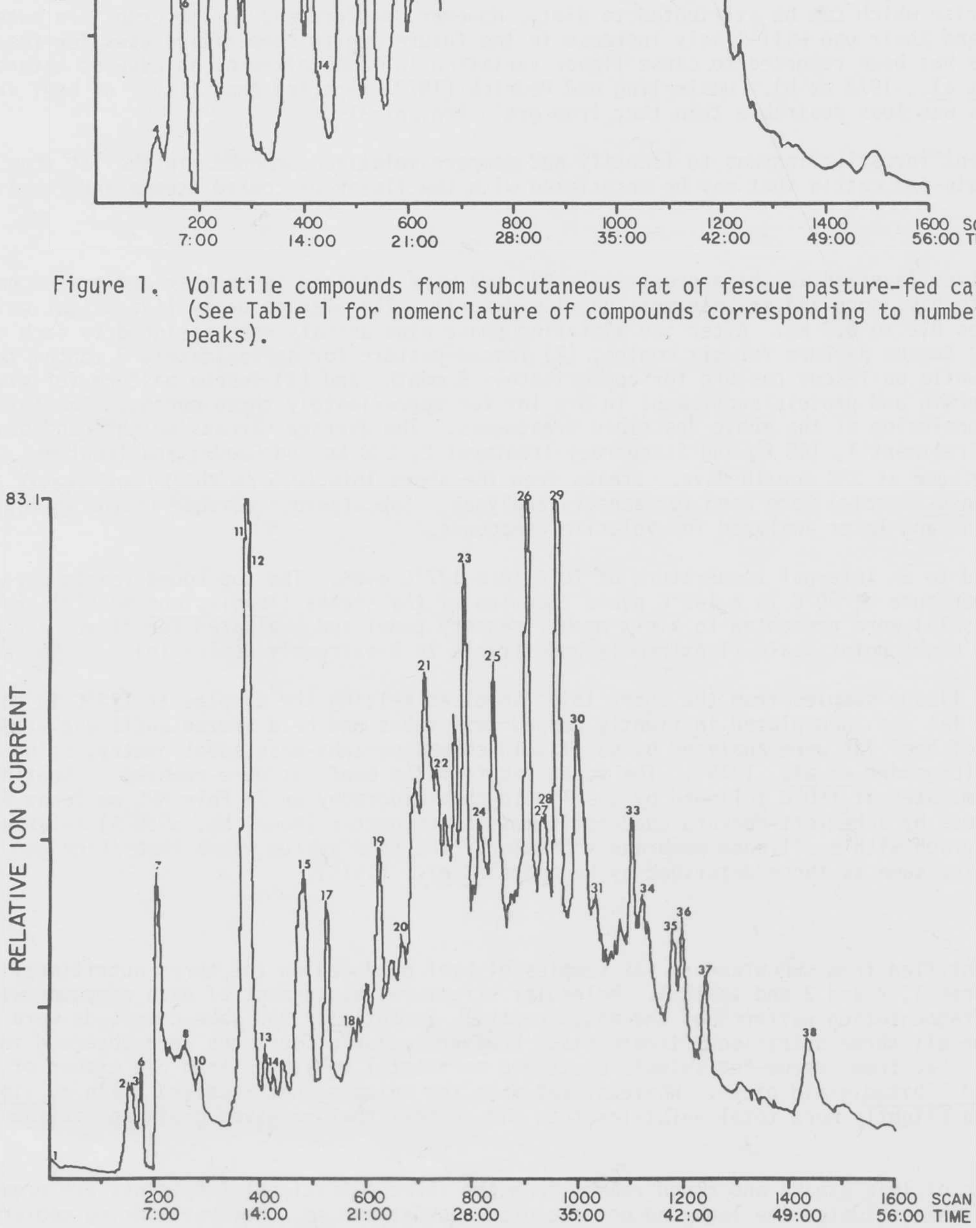

Figure 2. Volatile compounds from subcutaneous fat of cattle fed grain ad libitum on fescue pasture. (See Table 1 for nomenclature of compounds corresponding to numbers on peaks).

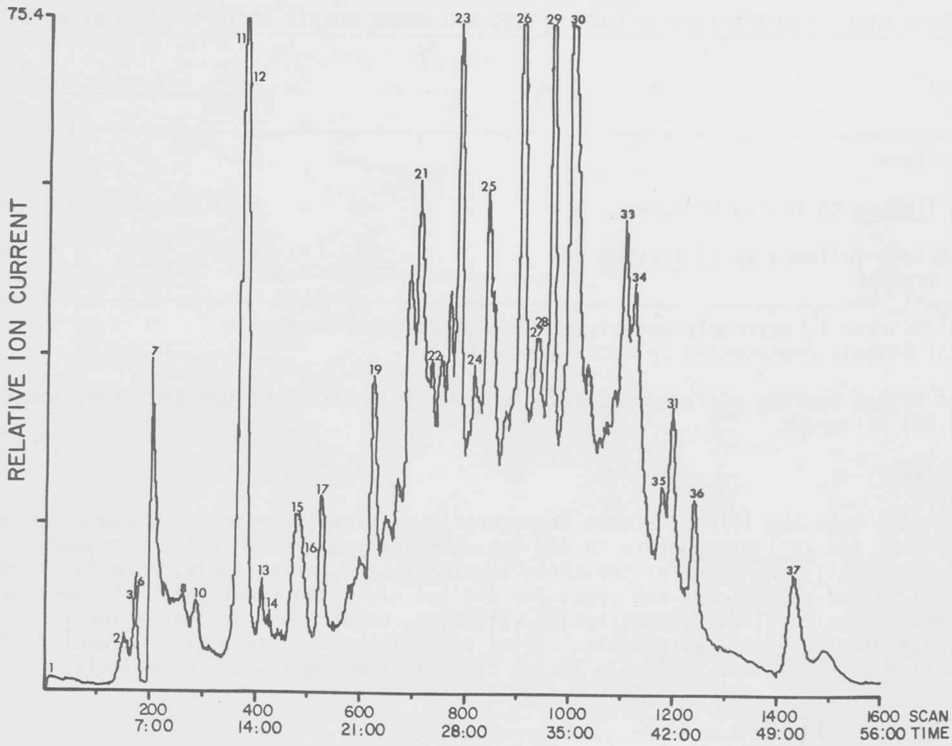

Figure 3. Volatile compounds from subcutaneous fat of cattle fed grain ad libitum in dry lot following fescue pasture. (See Table 1 for nomenclature of compounds corresponding to numbers on peaks).

Table 1. COMPOUNDS FROM BEEF FAT

Compound No.[a]	Compound name
1	Acetaldehyde
2	Pentane
3	Acetone
4	Trimethylamine
5	Propanal
6	Methylene chloride
7	Acetic acid
8	Hexane
9	Butanal
10	Chloroform
11	Benzene
12	Heptane
13	Pentanal
14	Methyl methacrolate
15	Octane
16	Toluene
17	Hexanal
18	Nonane
19	Heptanal
20	Dimethylpyrazine
21	Octanal
22	Dichlorobenzene
23	Nonanal
24	Methyl benzaldehyde
25-26	Unknown
27	Naphthalene
28	2,4 decadienal
29	Undecane
30	4-methyl-4-hepten-3-one
31	γ-lactone
33	C-12-methyl ketone
34	Octadecane
34	Δ-Decalactone
35	Diethylphthalate
36	Δ-Dodecalactone

Table 2. CONCENTRATION OF VOLATILES FROM FAT OF CATTLE ON DIFFERENT NUTRITIONAL REGIMENS.

Nutritional treatment	Animal number	Volatile concentration[a] Total	Peak 1100 scan	Peaks 800-1000 scan
Fescue pasture	79	1002.9	147.2	63.3
	57	1565.2	133.8	94.1
	32	1864.5	136.0	103.0
	Avg.	1477.5	139.0	86.8
Grain ad libitum on fescue pasture	82	801.0	35.5	50.0
	112	811.0	33.2	69.9
	128	1015.0	34.8	67.2
	Avg.	875.7	34.5	62.4
Fescue pasture followed by ad libitum grain in dry lot	59	855.0	26.8	57.0
	44	849.0	20.2	37.0
	65	722.0	38.5	45.5
	Avg.	825.3	28.5	46.5

[a]Estimation of volatile concentration obtained by weighing selected peaks from chromatograms (Figures 1, 2 and 3).

Table 1. COMPOUNDS FROM BEEF FAT (cont.)

Compound No.[a]	Compound name
37	Δ-Tetradecalactone
38	Δ-Hexadecalactone

Table 3. MEAN SENSORY PANEL FLAVOR SCORES OF LOIN STEAKS AND ROUND ROASTS AS INFLUENCED BY NUTRITIONAL REGIMEN.

Nutritional treatment	Flavor scores[a]	
	Steaks	Roasts
Fescue pasture	5.07[b]	5.21[b]
Grain *ad libitum* on fescue pasture	6.21[c]	6.20[c]
Fescue pasture followed by *ad libitum* grain in dry lot	6.48[d]	6.17[c]

[a]Range of scores: 1, extremely undesirable to 8, extremely desirable. Number of animals represented by each value was 27.

[b,c,d]Mean values bearing different superscripts within the same column are significantly ($P<.05$) different.

SUMMARY AND CONCLUSIONS

Subcutaneous fat samples from the loin of steers from three nutritional treatments, fescue pasture, *ad libitum* grain on fescue pasture, and *ad libitum* grain in dry lot were analyzed for volatile compounds. Qualitatively, the compounds were essentially the same for the three treatments. Quantitatively, more total volatiles were present in the fat of fescue-fed animals and least for the two grain-fed treatments. Sensory panel scores of loin steaks and round roasts paralleled quantitative volatiles, being least desirable for fescue pasture-fed animals and most desirable for grain-fed animals. Total volatiles and certain high molecular weight compounds appear to be associated with the less desirable flavor of meat from the fescue-fed animals.

LITERATURE CITED

Hornstein, Irwin and Patrick J. Crowe. 1964. Meat flavor-A review. J. Gas Chromatography 2:128.

Legendre, M. G., G. S. Fisher, W. H. Schuller, H. P. Dupuy and E. T. Rayner. 1979. Novel technique for the analysis of volatiles in aqueous and nonaqueous systems. J. Amer. Oil Chemists Soc. 56:552.

Park, R. J., J. L. Corbett and E. P. Furnival. 1972a. Flavour differences in meat from lambs grazed on lucerne (Medicago sativa) or phalaris (Phalaris tuberosa) pastures. J. Agr. Sci., Camb. 78:47.

Park, R. J., R. A. Spurway and J. L. Wheeler. 1972b. Flavour differences in meat from sheep grazed on pasture or winter forage crops. J. Agr. Sci., Camb. 78:53.

Patterson, R. L. S. 1975. The flavour of meat. In Meat, edited by D. J. A. Cole and R. A. Lawrie. Butter-worth & Co., London.

Shorland, F. B., Z. Czochanska, M. Moy, R. A. Barton and A. L. Ral. 1970. Influence of pasture species on the flavour, odour and keeping quality of lamb and mutton. J. Sci. Fd. Agr. 21:1.

Wasserman, Aaron E. and Ann Marie Spinelli. 1972. Effect of some water-soluble components on aroma of heated adipose tissue. J. Agric. and Food Chem. 20:171.

Watanabe, Kinji and Yasushi Sato. 1971. Gas chromatographic and mass spectral analysis of heated flavor compounds of beef fats. Agr. Biol. Chem. 35:756.

Westerling, David B. and H. B. Hedrick. 1979. Fatty acid composition of bovine lipids as influenced by diet, sex and anatomical location and relationship to sensory characteristics. J. Anim. Sci. 48:1343.