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VENISON FLAVOR: STUDY OF VOLATILE COMPOUNDS IN COOKED DEER MEAT

by

Praful C. Vin

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Food Science and Technology

UTAH STATE UNIVERSITY
Logan, Utah

1965

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ACKNOWLEDGEMENTS

I wish to extend to Dr. E. B. Wilcox, my major professor, my sincere thanks for her valuable guidance and inspiration throughout the work, but without which this thesis would not have been possible.

Gratitude and thanks must also go to Dr. J. B. Low for the assistance and encouragement rendered by him throughout the duration of research program.

Valuable suggestions during the work and proper criticism of this manuscript by Dr. Joseph C. Street and Professor Paul B. Larsen made the completion of the writing more enjoyable and of higher quality through their efforts.

I am also indebted to Dr. D. K. Salunkhe for his moral support and inspiration and to my fellow workers for their help during the work.

Financial support was generously given by Utah Fish and Game Department, through federal aid project W-97-R-6. Acknowledgements are made of assistance of conservation officers and other personnel of the Department in collection and handling of venison samples.

Praful C. Vin

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INTRODUCTION

Venison meat has a characteristic flavor which is acceptable if mild but some venison has a strong and objectionable flavor. The subject is of practical importance where deer is hunted as sport and for food. Each year in the State of Utah, over 180,000 hunters go in search of deer and over 130,000 animals are killed. This contributes about 10 1/2 million dollars to the economy of the state from licenses, lodging, transportation and other expenses of hunting. The problem is not only important in Utah but also in the U. S. A. and other parts of the world where venison is available and included in the diet. Little work has been done in the study of the components which give venison its characteristic flavor.

Today, flavor chemistry is relatively a new field. Kurtz (1959) defines flavor as complex sensations resulting from the stimulation of the senses of odor, taste, feel, and sometimes vision and audition. Gas-liquid chromatography is a powerful tool to a flavor chemist. The first classical paper describing both the gas-liquid partition technique and a relatively simple apparatus for resolving the aliphatic acids was published in the year 1952 by James and Martin. In 1956 the number of published papers was approximately 200. By 1960, the use of this technique had increased tremendously as evidenced by the fact that the number of publications were then about 1700. Application of this technique has resulted in a number of papers on volatile compounds in various foods. The ultimate aim of studying these volatiles is to make

it possible to improve the flavor of food products. The editor of Food Technology (Stewart, 1963) has stated that flavor is a challenge to a food technologist and that he has to answer such questions as:

1. Does the volatile compound which has been identified in the sample have sensory properities?

2. If so, what is its nature?

3. What combinations of components result in the sensory properties typical of the original product from which they were derived?

Only after the studies have been made will we know the significance of these volatile compounds.

The present study is a second phase in a project on investigation of venison quality and palatability being made under a federal aid project (W-97-R) through the Utah Department of Fish and Game. These phases include (a) the effects of field care, aging and cooking on the venison meats and (b) flavor components, their presence, distribution and factors affecting the amounts of these components.

In the previous work on item (b) above, a comparative study of water soluble flavor precursors of venison and beef was made (Reddy, 1964).

The present study deals with the nature of volatile compounds in cooked venison samples and determination of differences in venison flavor in animals of different ages, sexes, and season of kill. Evaluation of flavor was also made by a panel of judges.

REVIEW OF LITERATURE

In this review an attempt is made to co-ordinate various papers published on meat flavor.

The present survey indicates that very little work has been done on deer meat compared to other types of meats. However, the method used for one type of meat can be used with other types of meats including venison.

Barbella et al. in 1936 observed that the feeding regimen of lambs influenced the flavor. Howe and Barbella (1937) believed that there are certain inherent flavors in the fat of meat that are characteristic of the species, which becomes evident when the fat is heated. The age of the animal has an important influence on flavor of the meat.

Crocker (1948) reported that the flavor of raw meat is mainly confined to the juices, whereas cooked meat flavor appears to be due to chemical changes occurring in the fiber rather than in the juice. The intensity of flavor in various meat and meat juice fractions was investigated by Kramlich and Pearson (1958). They found that flavor varied greatly between the raw and cooked fractions, yet upon heating the raw fractions, the flavor appeared to differ only in intensity. Their results also showed that flavor constituents were largely water soluble in both cooked and raw fractions. However, cooking prior to extraction increased the flavor threshhold, indicating that full flavor development may be due to heating of the juice and fibers together. Barylko-Pilielana (1957) reported that

taste panel evaluation indicated that the typical flavor of roast beef was present in the water insoluble residue, but the water soluble fraction of roast beef had an intense but typical flavor.

Perhaps the first attempt of the present approach to the problem of meat flavor was made by Wood and Bender (1957). They isolated and identified 30 volatile and nonvolatile compounds from ox-muscle extract. Pippen et al. (1959) separated and identified 18 volatile carbonyl compounds of cooked chicken. A method was described in 1959 by Gaddis for the estimation in fat of total steam volatile carbonyls and mono- and dicarbonyl-fractions as dinitro phenyl hydrazine derivatives. Hornstein et al. (1960) identified acetone, acetaldehyde, formaldehyde, hydrogen sulfide, ammonia, and methylamine from volatile fractions of raw ground beef heated in a vacuum. They also indicated that flavor precursors are water soluble. In the volatile fraction from cooked beef the presence of carbon dioxide, acetone, acetaldehyde, methyl mercaptan, and methyl sulfide was reported by Kramlich and Pearson (1960).

Batzer et al. (1960) found that dialysis of the water extract of uncooked ground beef gives a diffusate which after lyophilization is capable of producing an odor similar to that of broiled steak when heated with fat and a beef broth odor and flavor when boiled in water.

Hornstein and Crowe (1960) showed by gas-chromatograms of lyophilized cold water extracts of lean beef and lean pork that odor responses and chemical compounds were similar in nature. They believe that the flavor difference that exists in pork and beef may have its origin in the fat portions of these meats.

In further investigations (1961) they found that lean beef and lean pork contain desirable meat flavor precursors, whereas the lipids, especially phospholipids contribute undesirable meaty flavors. The role of phospholipids in accelerating flavor deterioration in cooked meats was also reported by Youngsthan and Watts (1960). Hornstein and Crowe (1963) showed that the characteristic odor of heated lamb is from the fat portion. Their work suggests that difference in various meat flavors is due to the difference in the fat portion.

A comparative gas-chromatographic study of lyophilized cold water extracts of venison and beef was made by Reddy (1964). He showed the gas-chromatograms were similar in nature, but there was a difference in certain peak areas obtained from strong and mild flavored venison.

Hall et al. (1962) studied the effect of free fatty acid on flavor of fat under vivo conditions. They found that when heavy hogs were hauled 50 miles before slaughter and rested for 16 hours without feed, the raw back fat in many cases had higher acid numbers than those found in fed animals or hogs rested for shorter periods. The fats with higher acid numbers rated higher flavor scores.

Batzer et al. (1962) found that some of the precursors of meat (beef) flavor constitute a relatively simple mixture of glucose, inosinic acid and a glycoprotein. Certain of the amino acids in glycoprotein are necessary precursors of meat flavor. Recently Macy et al. (1964) reported a qualitative and quantitative study of certain amino acids, carbohydrates, amino acid nitrogen compounds and phosphoric acid esters in beef, pork, and lamb before and

after heating. In all three species, taurine, anserine, anserine-carnosine and alanine were present in relatively large quantities, and losses of these were large during heating. Other amino acids degraded during heating were: glutamic acid, glycine, lysine, serine, cystine, methionine, leucine, isoleucine, and methyl histidine. Heating caused marked increases of phosphoethanolamine in samples from the three animal species studied. Ribose was the carbohydrate most labile to heating and glucose was the most stable.

MATERIALS AND METHODS

Preparations of samples

The samples were prepared by a method similar to that described by Craig et al. (1962). It is known that full flavor development takes place only after heating. It may also be true that characteristic venison flavor of the meat is produced only when it is heated. Because of this reason the samples were prepared from cooked meat.

The method used for gas chromatography analysis is applicable with raw ground meat if the water is removed from it by anhydrous Na_2So_4 or $CaSo_4$ tubes during the collection of volatiles, or by freeze-drying the samples before analysis. In this study samples were freeze-dried because of two reasons namely, (1) to improve the consistency of the results and (2) freeze-dried samples can be stored for a longer period of time without deterioration. During freeze-drying some of the volatiles might get lost but with the freeze-dried powder the actual equivalent weight of meat to be analyzed can be much larger than when the cooked meat, itself, is analyzed.

Twenty-five deer for the study were obtained by the Utah Department of Fish and Game according to the experimental design which is shown in Table 1. The animals represented four age groups by sex (male and female fawn, yearlings, mature, and old deer which were collected in October and mature deer collected in October, November, and December.) The semimembranosus muscles were

Table 1. Age, sex, and date of collection of deer for flavor study of the semimembranosus muscle from the hind quarter

Age of deer	Sex	Number of animals	Date of collection
		(Cooked meat samples)	
Fawn	Male	4	October 1964
Fawn	Female	4	October 1964
Yearlings	Male	4	October 1964
Yearlings	Female	4	October 1964
Mature	Male	4	Oct., Nov., Dec., 1964
Mature	Female	4	October 1964
Old	Female	1	October 1964

taken from the various deer, frozen, and stored under commercial locker conditions: the right muscle was used for analysis of flavor components by gas-chromatorgraphy; the left muscle for flavor evaluation by a panel of judges.

Samples for analysis on the gas-chromatograph were prepared as follows:

From the frozen semimembranosus muscle a piece (more than 100 gms) was taken from the center with the help of a saw. This sample was thawed and cut into smaller pieces and 100 gms of the same were placed in a 250 ml Erlenmeyer flask. The sample was then heated in a paraffin oil bath held at 100° C, until all the juice came out of the meat and the mixture started boiling. The flask was removed from the paraffin oil bath and was brought to room temperature. The entire contents was transferred quantitatively to a Waring blender with 100 ml of cold water and blended 3 minutes. Then 50 gms of the slurry was placed in a petri dish and freeze-dried in a semi-commercial freeze-dryer.

All the freeze-dried samples were weighed and refrigerated in air tight containers.

Gas chromatography analysis of samples

Gas chromatographic analysis of volatiles in the samples was done by the method as reported by Hornstein and Crowe (1962).

Apparatus. The gas chromatograph was an Aerograph Model 600 C, equipped with a flame ionization detector and incorporating linear temperature

programming. The insulated column heating chamber had a 6 inch inner diameter and was 4 1/2 inches in height. The column described was fitted to these dimensions.

Column. The column of 0.025 inches inner diameter was 7.5 feet long and packed with 20 per cent castor wax on 30 to 60 mesh acid-washed chromosorb W (Table 2). The column was divided into two sections joined by a swagelock union: A 5.5 foot section coiled into a helix, 2 1/4 inches diameter; and a 2 foot section coiled into a helix with a 1 inch inner diameter. The ends of this small coil were so arranged that the coil could be conveniently suspended in a small Dewar flask.

Method. Figure 1 shows the assembly for collecting volatiles. A weighed amount of the freeze-dried sample (0.5 gms) was placed in a 250 ml Erlenmeyer flask. This was heated in a paraffin oil bath at the temperature of 125° C for 20 minutes. The sweep gas was water-pumped nitrogen which was purified by passage through a Linde molecular seive column. The exit tube leading to the collection coil was thick-walled glass tubing 0.25 inch outside diameter ending in a 0.25 inch fitting. A 0.25 inch tygon nut was used to connect to the 0.25 inch outside diameter collection coil and a 0.25 inch to 0.125 inch reducer was used to the 0.125 inch outside diameter collection coil. This coil was immersed in a Dewar flask containing liquid nitrogen (temperature, -196 C). The exit of the coil was attached to a drying tube and this is in turn to a soap bubble meter. The flow rate was 20-30 ml per minute and the sampling time was 20 minutes. Condensation of small amounts of water on the side arm from the sample during collection was prevented by the use of a current of

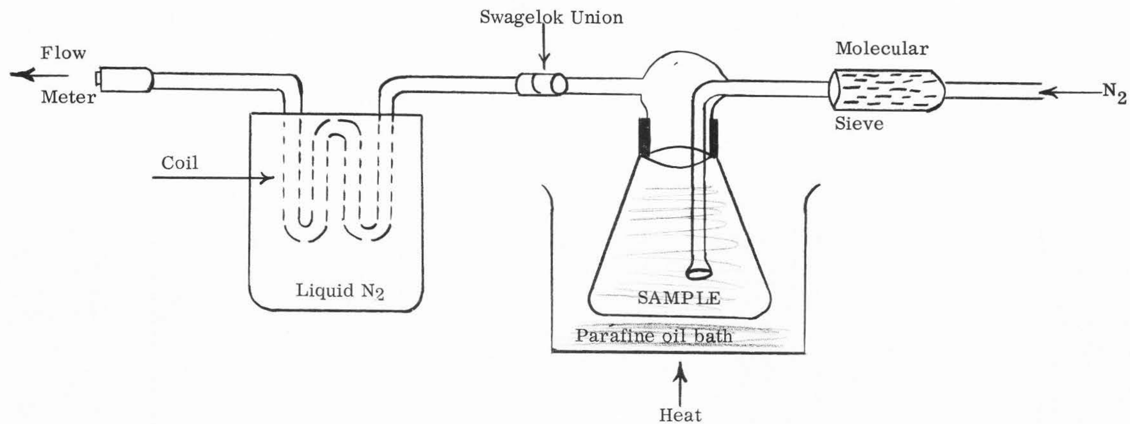

Figure 1. Assembly for collection of volatiles

hot air. At the completion of the run the nitrogen flow was stopped. The exit end of the collection coil was immediately coupled to the main section of the column. The connection to the sample flask was detached and this end of the coil sealed with a Swagelok plug. The coil was removed from the liquid nitrogen and was brought to room temperature. The plug was then removed and the odor checked by smelling it. The composite column was placed in the heating area of the gas chromatograph. A slight positive nitrogen pressure was applied and the flame ignited. After 5 minutes the nitrogen flow was adjusted to 12 ml per minute and the temperature programming started.

Other gas chromatographic operating conditions are shown in Table 2.

Panel evaluation flavor of venison samples

The left semimembranosus muscles from different animals were roasted and evaluated for flavor by a panel of eight judges using the technique described by Bardwell (1964). Moist heat was used for the roasting. Samples were rated for flavor on the hedonic scale used by Peryam and Gerardot (1952). The ratings of the judges, from 'like extremely' to 'dislike extremely' were given scores of 1 to 9, with the best score being 9.

Table 2. Gas chromatographic operating conditions used in the study

Sample size, grams	0.5
Column length, feet[a]	7.5
Column inner diameter, inch	0.025
Column material	20 % castorwax on 30/60 Chromosorb W
Hydrogen flow rate, ml/min	30
Nitrogen flow rate, ml/min	12
Starting temperature, C	35
Programming temperature, C/min rise	4
Final temperature, C	125
Sensitivity (range)	10
Starting attenuation	1-32
Attenuation at 50 C Column temperature	1-2

[a]Constructed of stainless steel tubing

RESULTS AND DISCUSSION

Gas chromatographic analysis

Before the analyses of samples were started the method was checked with a known standard sample containing pure acetone, isopropanol, isobutanol, and n-butanol in equal quantity. In Figure 2 is shown the gas chromatogram of this standard mixture when 1 μl of it was injected in a conventional manner with temperature programming. The chromatogram of the standard mixture obtained by the method reported by Hornstein et al. (1962) in which the volatiles are collected in a part of the coil immersed in liquid nitrogen is presented in Figure 3. The peak area values obtained by both the methods were almost identical indicating the reproducibility of the method to be used for the analysis of venison samples. Analyses of the standard sample by one or both methods was used periodically as a check during the analysis of venison samples (8 to 10 times). In Table 3 is shown the peak area value obtained from chromatograms of 1 μl of the standard mixture by both the methods.

In general six peaks were obtained from the venison samples. In a few cases one or two extra peaks were obtained. The peaks were numbered for their identification on the basis of their retention time value, i.e. peaks having the same number had the same retention time in different samples. The retention time values was constant in most of the cases. Peak area values were

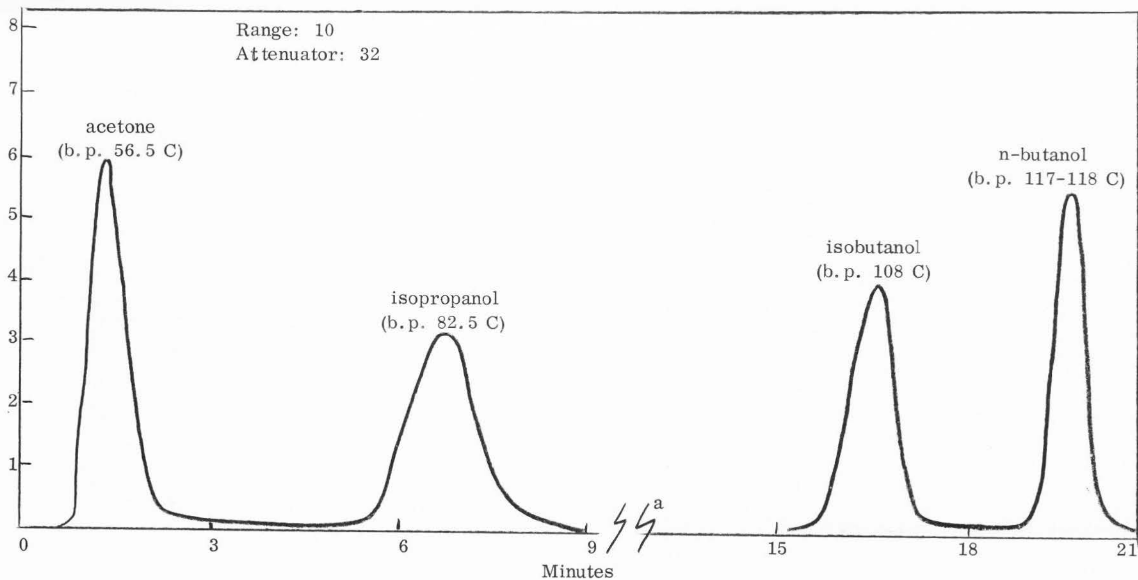

Figure 2. Gas chromatogram of 1 μℓ of standard mixture when the sample was injected in a conventional method with programming

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[a] Fold equivalent to 6 minutes run

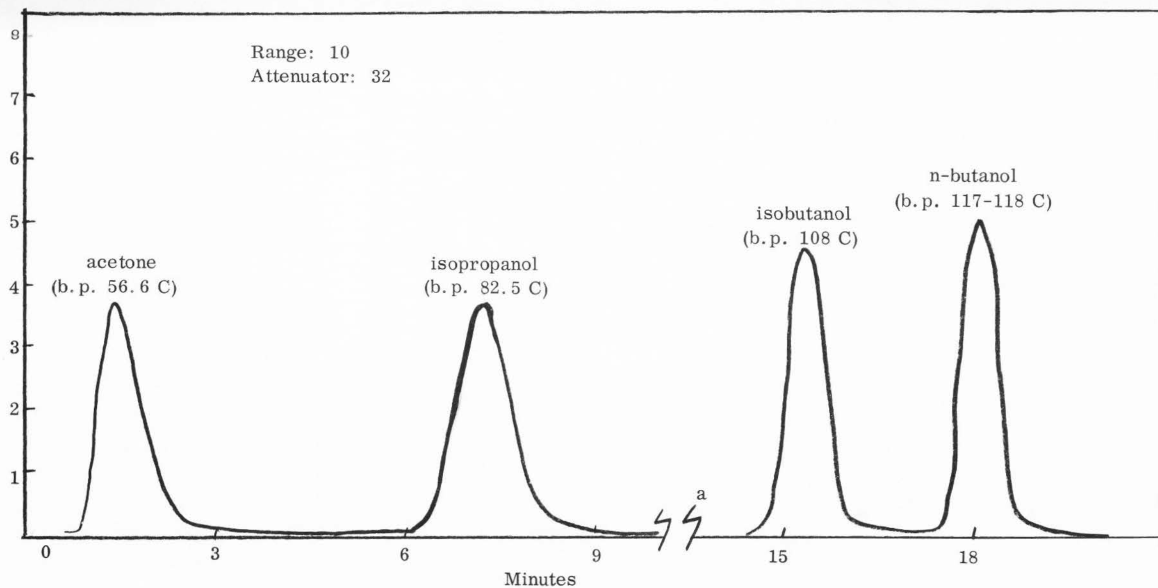

Figure 3. Gas chromatogram of 1 $\mu\ell$ of a standard mixture when volatiles were collected in a part of coil immersed in liquid nitrogen

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[a]Fold equivalent to 6 minutes run

Table 3. Peak areas from chromatograms of a pure mixture containing acetone, butanol, iso-butanol, and iso-propanol in equal quantity; when 1 ul was was injected in a conventional manner and when 1 ul was collected in a coil

	Peak area in square centimeters			
Method	Acetone	Butanol	Iso-butanol	Iso-propanol
Sample injection	215	180	152	190
	216	194	160	192
	192	198	177	200
Collector coil	170	190	147	171
	218	160	160	163
	170	200	160	160

calculated by use of a planimeter or by the Cremer and Muller (1951) method. To improve the consistancy of peak area values between duplicates on the same sample, heat treatment of the sample, flow rate of carrier gas during collection of volatiles, and starting temperature of oven while taking a chromatogram were well controlled.

Even with all conditions of assay rigidly controlled, peak areas between chromatograms of the same sample were not always identical, therefore, most samples were analyzed in duplicate or triplicate. Peak area values for duplicates of representative samples are shown in Table 4. In most cases the values obtained were identical or similar except in the case of peak 1, therefore, peak 1 was not considered reliable for use in the interpretation of the data.

In Figure 4 is presented a typical chromatogram of cooked deer meat having venison flavor. The attenuation conditions for the first three peaks of different samples varied from 1-16 and for the remaining peaks, 1 to 2. Retention times are shown in Table 5.

Although variations in peak areas between animals within the same age and sex group were relatively great yet mean values do suggest some trends. Peak areas of the chromotograms in square centimeters per 100 grams of meat, for each animal are presented in Table 5; mean peak values, in Table 6; and classification of the flavor of each animal by the judges, in Table 7. No one animal among those which had a true venison flavor had a particularily strong venison odor and flavor, hence, the 14 animals having venison flavor are grouped together in this discussion. Mean peak values of meat which had

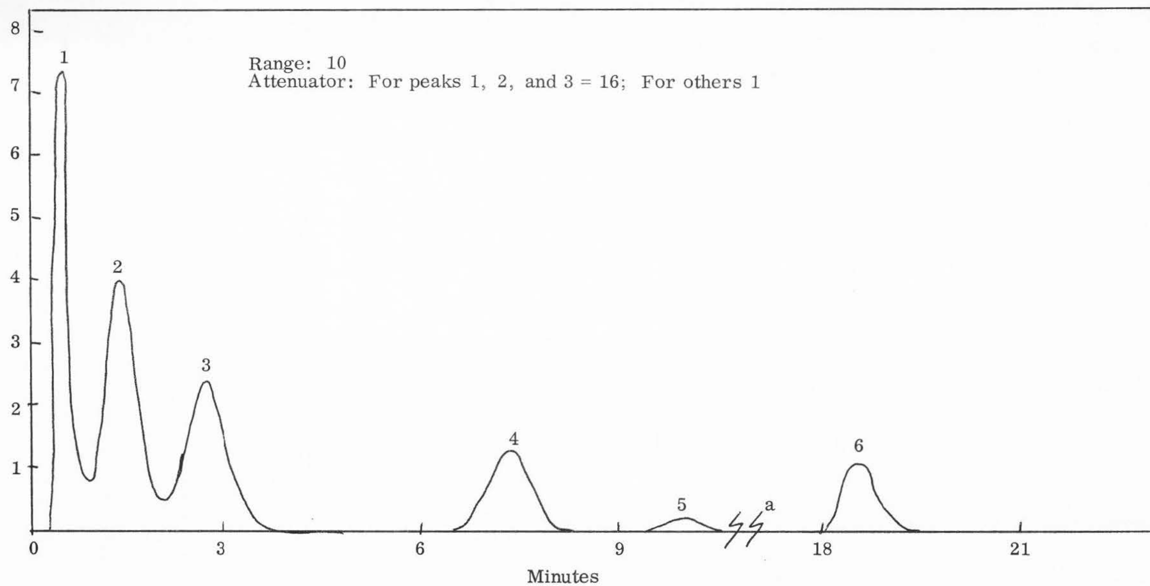

Figure 4. A typical gas chromatogram of volatile components isolated from cooked deer meat having venison odor and flavor

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[a]Fold equivalent to 9 minutes run

Table 4. Peak areas for volatile components for duplicates of representative samples of deer meat

Animal number	Sample number	Peak area in square centimeters					
		Peak 1	Peak 2	Peak 3	Peak 4	Peak 5	Peak 6
A	1	226	385	85	163	164	—
	2	156	355	70	148	119	
B	1	262	36	—	20	95	85
	2	614	25	—	22	60	38
C	1	15	11	743	119	30	—
	2	8	11	637	115	28	—
D	1	572	42	795	—	583	153
	2	572	32	848	—	593	140
E	1	253	207	194	65	11	52
	2	302	102	170	63	20	45

Table 5. Peak areas from chromatograms of volatile components per 100 grams of cooked deer meat

Animal number	Age and sex	Peak area in square centimeter						Extra peaks	Total of peak areas
		Peak 1	Peak 2	Peak 3	Peak 4	Peak 5	Peak 6		
		31.5 sec.[a]	2.15 min.[a]	2.77 min[a]	6.8 min[a]	9.75 min[a]	18.37 min[a]		cm^2
1	Fawn male	2642	1651	619	247	93	7		5259
2	Fawn male	2112	40	32	——	4	——	After peak 3-area 20	2208
3	Fawn male	9	124	20	60	707	——		920
4	Fawn male	3	109	——	125	300	——		537
5	Fawn female	16	——	89	6	25	——	After peak 5-area, 10	146
6	Fawn female	391	10	23	56	46	——		526
7	Fawn female	917	——	164	54	208	——		1343
8	Fawn female	1677	259	60	42	149	3		2189
9	Yearling male	3349	74	——	14	34	202	Two after peak 6-area, 20 and 11	3704
10	Yearling male	266	8	637	32	122	32		1097
11	Yearling male	138	346	173	60	114	——	After peak 3-area, 10	841
12	Yearling male	10	18	26	58	102	——	After peak 3-area, 19	233
13	Yearling female	438	27	82	151	121	15		834
14	Yearling female	720	11	202	45	111	34		1123

Table 5. Continued

Animal number	Age and sex	Peak area in square centimeters						Extra peaks	Total of peak area
		Peak 1	Peak 2	Peak 3	Peak 4	Peak 5	Peak 6		
		31.5 sec.[a]	2.15 min.[a]	2.77 min.[a]	6.8 min.[a]	9.75 min.[a]	18.37 min.[a]		cm^2
15	Yearling female	831	140	76	——	3	——		1050
16	Yearling female	765	170	80	9	29	——	After peak 6-area 3	956
17	Mature male	249	11	113	28	166	142	Two after peak 3-area,21 and 45	775
18	Mature male	1969	213	1618	106	16	13		3935
19	Mature male	1846	3747	466	116	——	——	After peak 6-area, 7	6182
20	Mature male	428	9	33	24	39	——	After peak 5-area, 8	541
21	Mature female	——	16	494	24	344	8		886
22	Mature female	——	75	79	38	60	24		276
23	Mature female	2533	2070	1940	65	11	52		6671
24	Mature female	268	1474	726	53	6	——	After peak 3, area, 179	2705
25	Old female	2723	255	85	5	249	——		3317

[a]Retention time

Table 6. Effect of sex, age, and month of harvest on peak areas from chromatograms of volatile components from cooked deer meat

Items	Mean peak value in square centimeter per 100 grams of meat[a]						
	1	2	3	4	5	6	Total peaks
<u>Flavor</u>							
With venison flavor	1287(13)	471(14)	521(13)	74(14)	106(14)	42(9)	2380(14)
No venison flavor	756(10)	475(9)	145(11)	42(9)	157(10)	75(2)	1356(11)
<u>Sex</u>							
<u>Male</u>							
With venison flavor	1468(7)	345(7)	514(6)	94(7)	135(7)	62(3)	2229(7)
No venison flavor	929(5)	786(5)	133(5)	57(4)	230(4)	141(1)	2125(5)
<u>Female</u>							
With venison flavor	1194(6)	595(7)	453(7)	57(7)	100(7)	26(4)	2532(7)
No venison flavor	424(5)	84(4)	154(6)	30(5)	109(6)	8(1)	716(6)
<u>Age</u>							
<u>Fawn</u>							
With venison flavor	1440(3)	673(3)	336(2)	138(3)	181(3)	5(2)	2662(3)
No venison flavor	689(5)	58(3)	65(5)	44(4)	197(5)	0(5)	1029(5)
<u>Yearling</u>							
With venison flavor	820(6)	81(6)	224(5)	60(6)	100(6)	70(4)	1305(6)
No venison flavor	798(2)	155(2)	77(2)	9(1)	16(2)	0(2)	1003(2)

Table 6. Continued

Items	Mean peak value in square centimeter per 100 grams of meat						
	1	2	3	4	5	6	Total peaks
Mature							
With venison flavor	1590(3)	960(4)	1090(4)	65(4)	23(4)	30(3)	3549(4)
No venison flavor	841(3)	960(4)	276(4)	48(4)	183(3)	75(2)	1944(4)
Age by sex							
Fawn male							
With venison flavor	1322(2)	880(2)	619(1)	186(2)	196(2)	7(1)	2898(2)
No venison flavor	1060(2)	82(2)	26(2)	60(1)	355(2)	0(2)	1564(2)
Fawn female							
With venison flavor	1677	259	60	42	149	3	2189(1)
No venison flavor	441(3)	10(1)	92(3)	39(3)	93(3)	0(3)	672(3)
Yearling male							
With venison flavor	991(4)	111(4)	279(3)	41(4)	93(4)	117(2)	1469(4)
No venison flavor	——	——	——	——	——	——	——(0)
Yearling female							
With venison flavor	579(2)	19(2)	142(2)	98(2)	112(2)	24(2)	978(2)
No venison flavor	798(2)	155(2)	78(2)	9(1)	16(2)	0(2)	1003(2)
Mature male							
With venison flavor	1969	213	1618	106	16	13	3935(1)
No venison flavor	848(3)	1237(3)	204(3)	56(3)	69(2)	141(1)	2499(3)

Table 6. Continued

Items	Mean peak value in square centimeters per 100 grams of meat						
	1	2	3	4	5	6	Total peaks
Mature female							
With venison flavor	1401(2)	1206(3)	915(3)	52(3)	25(3)	28(2)	3421(3)
No venison flavor	——	16	494	24	344	8	886(1)
Old female							
With venison flavor	2823	255	85	5	249	——	3317(1)
Month of harvest							
October							
With venison flavor	1983(4)	401(5)	452(4)	72(5)	148(5)	50(5)	2627(5)
No venison flavor	824(4)	42(3)	119(5)	32(4)	93(5)	16(2)	950(5)
November							
With venison flavor	1094(6)	454(6)	418(6)	64(6)	85(6)	34(3)	2170(6)
No venison flavor	420(2)	132(2)	48(2)	60(1)	355(2)	0(2)	985(2)
December							
With venison flavor	746(3)	598(3)	1172(3)	95(3)	107(3)	13(1)	2392(3)
No venison flavor	857(4)	984(4)	150(4)	52(4)	22(4)	0(4)	2051(4)

[a]Number in parenthesis after peak value represents number of animals

Table 7. Flavor score and comments of judges of the venison samples

Animal number	Age and sex of animal	Flavor score[a]	Comments of judges
1	Fawn male	7.0	Good venison odor and flavor[b]
2	Fawn male	7.7	Flavor of very good meat, but not venison
3	Fawn male	5.0	Undesirable and off-flavor, but not venison
4	Fawn male	6.8	Slight venison odor and flavor
5	Fawn female	6.8	Off-flavor, but not venison
6	Fawn female	6.7	Slight unpleasant odor and flavor, but not venison
7	Fawn female	7.8	Flavor of very good meat but not venison
8	Fawn female	5.0	Venison odor and flavor
9	Yearling male	6.8	Venison odor and flavor
10	Yearling male	7.0	Slight venison odor and flavor
11	Yearling male	7.8	Venison odor and flavor
12	Yearling male	7.4	Venison odor and flavor
13	Yearling female	7.0	Venison odor and flavor
14	Yearling female	7.0	Venison odor and flavor
15	Yearling female	5.7	Flavor of meat, but not venison
16	Yearling female	7.5	Flavor of good meat, but not venison
17	Mature male	7.5	Flavor of good meat, but not venison
18	Mature male	6.6	Venison odor and flavor
19	Mature male	6.5	Flavor of meat, but not venison
20	Mature male	6.0	Flavor of meat, but not venison
21	Mature female	7.0	Venison odor and flavor
22	Mature female	6.7	Slight off flavor but not venison
23	Mature female	6.0	Venison odor and flavor
24	Mature female	6.0	Venison odor and flavor
25	Old female	6.8	Venison odor and flavor

[a]1-9 with 9 being meat with best score
[b]Normal venison flavor

a distinct odor and flavor of venison were higher for most of the peaks when compared to those from animals not having a true venison flavor. The total peak area for the venison flavored meat was 2337 cm^2 as compared to 1418 cm^2 for meat not having a venison flavor. The mean values for peaks 1, 3, and 4 were much greater for the venison flavored meat than for the meat without a venison flavor. The meat from 9 out of 14 animals with a venison flavor showed peak 6 while no peak 6 appeared for 9 out of 11 animals not having a venison flavor. This comparison would appear to be more valid than looking at the means for peak 6. Thus, peak 6 seemed to be measuring certain components of the venison flavor which were not found in the other meats.

Peak areas for meat with venison flavor from male animals were somewhat greater than for females for all peaks except peak 2. Similar differences occurred for meat not having a venison flavor. In this case peak 3 was the exception not peak 1.

To discuss differences as related to age, flavor scores by the panel of judges as well as classification into meat with or without a venison flavor must be considered. Flavor scores are presented in Table 7. Venison odor and flavor were present in some animals of each age and sex group. The flavor score varied from 5 to 7.8 with the high score indicating the best flavor. The maximum score possible was 9 and minimum was 1. In case of real strong venison flavor, the flavor score would be in the range of 1 to 3. In the present study no particular sample was found to score that low which indicated that no meat had a real strong flavor of venison. The mean flavor score was least in

mature animals (6.5) and was maximum in case of yearling animals (7.0) for the meat with a venison flavor. Some of the fawns scored high while some scored low. However, there seems to be no direct relationship existing between peak area value and the flavor score for meat with a venison flavor. The mean flavor score was least in mature animals and they also had high values for peak 2 and 3. This suggested that mature animals had a stronger flavor for which peaks 2 and 3 might be responsible (Table 6). In fact areas for peaks 1, 2, 3, and total of all peaks in mature animals were all approximately twice or more as large as for the yearlings.

Season of the year seemed to be related to flavor and peak area. Animals obtained in December which had a venison flavor tended to have lower flavor scores and higher peak area values than those found for October and November. In fact, peaks 1, 2, and 3, had areas that showed a linear increase with month of harvest from October to December. This finding is based on results from 5, 6, and 3 animals from October, November, and December, respectively.

The peaks number 4, 5, and 6, which have relatively less peak area value compared to other peaks might be even of more importance than peaks which have high values. Peak 6 being absent in many non-venison flavored animals while being present in many venison flavored animals might be critical in a study in which components of the various peaks would be identified. Burr (1964) believed that inherent odorness of a compound was inversely proportional to its olfactory threshhold in the vapor phase. The threshhold for organic

compounds covered a range of at least 7 orders of magnitude. Consequently, a very large peak on a chromatogram, if it was due to something like ethyl alcohol, may be of little or no importance to aroma while on the other hand, a very small peak, if due to an inherently smelly compound, such as methyl Marcaptan or beta-ionone, might be of dominating importance.

Conclusions

1. In the present investigation definite conclusions were difficult, as the range of flavor score available was not wide, and samples showed little differences in flavor scores. Samples with real strong venison flavor would have a low flavor score of 1 to 3. Such a sample was not found during this study.

2. Using large peak area values of the volatile components from chromatograms from meat which had a true venison flavor as indicating a more intense venison flavor and the small peak values to indicate a milder venison flavor, certain trends were found:

   a. Meat from male animals tended to be stronger than the meat from females. Peak areas tended to be larger for the males than for the females.

   b. Meat from yearling animals tended to be scored higher by the panel of judges and to have smaller peak areas for certain peaks than did the meat from mature animals.

   c. Meat harvested in October tended to have smaller peak areas than meat harvested in November which in turn were lower than values

for meat obtained in December. Flavor scores were also lower for December animals.

Recommendations

1. In the present study the role of fat in venison flavor has not been investigated. The literature indicates that the difference in characteristic flavor of different meats may reside in the fat portion. Further investigation is necessary regarding the role of fat in its contribution of venison flavor. Does the fat carry components that contribute to off-flavor in venison?

2. Chemical analysis for the identification of peaks is necessary. The different fractions of volatiles emerging from the column should be collected and analyzed by other chemical methods.

3. Thin layer chromotography should be used in the identification of flavor precursors and/or components.

4. Meat with a strong venison flavor should be obtained for anlaysis. The range of flavor may be wide, hence a strong flavored meat as well as mild flavored meat is needed for identification of the components.

5. Flavor components of cooked meat should be compared with those of uncooked meat.

SUMMARY

For the gas chromatographic analysis samples were prepared from the right semimembranosus muscles after cooking and freeze-drying from 25 animals representing different age, sex and season of harvest. The left semimembranosus muscle was roasted for panel evaluation. None of the animals were rated by the judges as having a strong venison flavor.

The basic pattern of the gas-chromatograms obtained for the volatile components from the cooked meat was similar but there was a difference in the peak area values. The peak areas were calculated and compared with the flavor score. Six peaks were obtained for most animals. In some cases extra peaks also appeared. As some animals did not have a true venison flavor when evaluated by the judges, all evaluation of data included two groups of animals, those with a true venison flavor and those without a venison flavor.

Peak areas tended to be larger for the male animals having a venison flavor than for females thus indicating that males had the stronger flavor.

The results did not indicate any direct relationship existing between peak area value and the flavor score. The mean flavor score and mean peak area value indicated that mature animals had the least flavor score and the highest peak area values while yearling animals scored higher for flavor and had lower peak area values.

The flavor of meat as indicated by peak area values decreased as the season progressed from October to December. That is, peak area values

increased. Flavor scores also tended to be lower for meat harvested in December as compared to the meat obtained in October or November.

In the present study the range of flavor was not wide which made conclusions more difficult.

Further investigation is necessary regarding the role of fat in the venison flavor, chemical analysis of the volatile compounds representing all peaks by collecting the fractions emerging from the column, and comparison of meat from real strong venison-flavored animals with that of mild-flavored venison.

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