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MEAT VOLATILES OF FIVE DIFERENT GOAT GENOTYPES

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Introduction

The high nutritional and climatic adaptation of goats, as well as the fact that they provide low fat meat, makes it an important protein source for hot dry climates as the Brazilian northeast region were most of Brazil's goats are located. They are there extensively reared under native pasture without feed supplementation constituting an important factor for the subsistence economy.

Brazilian herd is constituted of SRD animals – without a definite breed – originated from random crossbreeding between native (Canindé, Moxotó, Marota and Repartida) and foreign breeds from Asia, Africa and Europe. Though characterized as highly rustic they were not selected for meat production.

However, from 1992 to 2002 Brazilian demand for goat meat augmented 24.5% (COUTO, 2003). At the same time consumer demands for better quality meat also increased demanding better slaughter conditions, new breed introduction and younger animals. Yet, Brazilian goat meat is still considered as presenting strong flavor and tenderness problems limiting a stronger expansion of its consumption consolidating this activity as an important one for the Brazilian agribusiness.

Breed, age, sex and feeding regimen have been pointed as important factors affecting the characteristic flavor of goat meat (SOBRINHO e NETO, 2001; MADRUGA et al., 2003). Breed has been especially implicated as a factor of meat quality (SAÑUDO et al. 1998). However, few studies based on genetic group comparison have been conducted in Brazil. Evaluation of pure breeds and crossbreeds or both may provide information leading to opportunities for genetic improvement of goat meat quality.

Objectives

To obtain information allowing development of Brazilian goat herds with better meat flavor.

Methodology

F1 intact male goats were obtained from the EMEPA's Experimental Station of "Pendência", located in the Cariri region of Pernambuco State, Brazil, by crossbreeding Brazilian native (Moxotó and SRD) and foreign animals (Boer, Savanna, Kalahari and Anglo Nubian) as to constitute five genetic groups: ½ Moxotó + ½ Boer; ½ Boer + ½ SRD; ½ Savanna + ½ SRD; ½ Anglo Nubian + ½ SRD; ½ Kalahari + ½ SRD. Until four months of age they were raised under field conditions with their mothers feeding on brachiaria (*Brachiaria decumbens*), mombaça (*Panicum maximum*), pangola (*Digitaria eriantha*), and tiffton (*Cynodon* sp.) grass and supplemented with a concentrated mixture to provide their nutritional needs. They were then separated from their mothers and confined in collective pens for 60-65 days, receiving a concentrated mixture (89.9% of dry matter, 93% of organic matter, 18.6% of crude protein, 4.2% of fat, 32% of neutral detergent fiber, 14% of acid detergent fiber and 3,26 kcal/kg DM of digestible energy) of broken maize (50%), maniçoba hay (20%), soy bean meal (23%), vegetal oil (1%) and mineral salt (2%). By this time the animals were 6-6.5 month old and weighed between 18 and 28 kg.

After fasting for 24 hours with free access to water six animals of each genetic group were slaughtered. Hot carcasses were held at room temperature (25-30 ºC) for six to eight hours and chilled (–4 ºC ; 24 h). Chilled carcasses were dissected into bone and edible meat. Muscles from the left legs were frozen (-18 ^{o}C) until conduction of chemical analysis.

Volatile compound determination were conducted in the quadriceps muscle after volatile extraction by the simultaneous extraction and distillation technique (LIKENS & NICKERSON, 1964) followed by separation and identification in a GC-MS chromatrographer. Goat quadriceps muscle was defrosted overnight, and 150 g portions were cut into 1 cm^3 cubes which were cooked (~ 55 min) in a pre-heated (200 ºC) oven to an internal temperature of 75 ºC. Extraction of flavor volatile compounds (MADRUGA et al., 2000) was performed. Distilled volatiles were analyzed in a GC chromatographer (Shimadzu GC-17) connected to a QP 5050A mass spectrophotometer. A split/splitless (1:10) injector set at 230 °C was used to introduce 0.5 µL aliquots of each of the distillation extract onto a fused silica capillary column. The capillary column used was a DB-5; 30 m x 0,257 mm (i.d.) x 0,25 µm film thickness (US 1372916H - J&W Scientific Inc, UK). Helium at 1 ml/min was used as a carrier gas. The initial column temperature was set at 30 °C. Five minutes after injection the temperature was increased (20 °C/min) to 60 °C and maintained for 5 min. Then it was programmed to increase (4 °C/min), to a final temperature of 250 °C. The temperature was held at 250 °C for 10 min. Column end was connected to an ion source (250 ºC, ionization energy of 70 eV). The MS operated through an electron impact system with a 40 to 350 m/z mass variation amplitude and a scan rate of 1 scan/sec. Volatiles were identified by comparing their mass spectra with those of a NIST (National Institute of Standards & Technology, E.U.A.) computer data base library (150,000 reference spectra).

To calculate the linear retention indices (LRI) volatile compound, a solution containing C_6-C_{25} n-alkanes was run through the chromatographer before each run of the GC-MS (MADRUGA et al., 2000). LRI values were compared with those of literature

(JENNINGS & SHIBAMOYO, 1980; KONDJOYAN & BERDAGUÉ, 1996) authentic compounds.

Data from volatile compound composition were only descriptively analyzed since it was necessary to group the quadriceps muscles from the six animals of each genetic group to provide sufficient material.

Results & Discussion

Fifty one flavor volatiles peaks were identified (Table 1) as aldehydes (14), alcohols (10), hydrocarbons (9), ketones (7), esters (5), furans (2), aromatics (2) and terpenoids (2). Thirty eight were identified both by mass spectroscopy (MS) and comparison of their linear retention indexes (LRI) to those presented in the literature. The remaining 13 were identified only by MS. These compound classes have been pointed as the major ones in cooked goat meat volatiles (MADRUGA et al., 2000). The number of volatile compounds is lower than those (108) reported by MADRUGA et al. (2000) in mixed race goats of different age and gender. However, these authors only found 53 volatiles in similar animals (entire males slaughtered after 175 days).

Table 1 shows that, based on both relative area and number of volatiles, four classes stick out: aldehydes, alcohols, hydrocarbons and ketones, which are the major compounds in the aromatic profile of cooked meats (MADRUGA et al., 2003) resulting from thermal degradation of long chain fatty acids (MADRUGA et al., 2000).

Aldehydes are volatiles found in greater concentration and number. Their relative amount varied from 17.59% in the ½ Boer + ½ SRD to 63,65% in the ½ Anglo Nubiana + ½ SRD genetic group.

Aliphatic aldehydes have been associated with the characteristic goat meat odors (SUTHERLAND & AMES, 1995), but not in lamb (NIXON et al., 1979).

Furans, produced form Maillard thermal degradation of carbohydrates are important to beef and pork flavor but not widely identified in lamb and goat meat. However, alkyl furans, especially 2-pentil-furan, have been verified in almost every meat and may result from the ciclization of the 4-keto nonanal derived from linoleic acid (MOTTRAM, 1991).

Though expected as one of the major class of compounds, originating from the thermal degradation of sulfur-containing amino acids and from thiamine or Maillard reactions (MOTTRAM, 1991), especially in lean meats source such as goat, no sulfur volatiles were identified. On the contrary, most of the volatiles identified originate from fats (MOTTRAM, 1991; ELMORE et al., 1999). A possible reason for this absence of sulfur volatiles is the low cooking temperature (70 ^{o}C) since they are generated under higher (> 80 ^{o}C) cooking temperatures (MACLEOD & COPPOCK, 1977; LAWRIE, 1979; CAMBERO et al., 1992). However, MADRUGA et al. (2000) reported 2 sulfur volatiles (0.7% of the total volatiles) in similar animals (entire males slaughtered at 175 days of age) cooked to a similar internal temperature.

Similar to MADRUGA et al. (2000) no carboxylic acids were identified which is probably due to the fact that this class of compounds is not very volatile (MOTTRAM, 1991).

Among the identified volatiles five presented greater chromatographic areas in every genetic breed: hexadecanal, butylated hydroxytoluene (BHT), hexanal, nonanal and pentanol-2.

Hexadecanal was first identified in lamb (SUTHERLAND & AMES, 1995).

BHT detection in every sample analyzed is probably associated to the use of this antioxidant in animal feed.

Table 1 also shows that genetic group influenced the major groups of volatile compounds. Animals of the ½ Anglo Nubiana + ½ SRD genotype generated a greater proportion of aldehydes even though only 2 (hexadecanal and octadecanal) have been identified. Animals of this genetic group also presented significant amounts of BHT and insignificant amounts of the remaining volatile groups. Animals of the ½ Kalahari + ½ SRD genotype generated similar amounts of aldehydes (hexanal, benzaldehyde, nonanal and hexadecanal) and aromatic compounds (BHT) which, together, accounted for 72.48% of all volatile identified. Except for terpenoids, though in smaller amounts, the remaining volatile groups are also present in the meat volatile profile of this genetic group. Animals of the ½ Moxotó + ½ Bôer genotype generated greater amounts of aldehydes (all of the 14 identified) which, together with 9 different alcohols (20,25%) and 2 aromatics (25,04%) make up 94.58% of all volatiles. Animals of the ½ Savanna + ½ SRD genotype were characterized by greater generation of aromatic compounds (BHT and toluene – 56.1%) and 5 different aldehydes (2-methyl butanal, hexanal, octanal, nonanal e hexadecanal) which together account for 89.73% of all volatiles. Finally, ½ Bôer + ½ SRD animals were characterized by the greater generation of aromatic volatiles (BHT and toluene – 38.9%) and 7 different alcohols (35.81%) which together with 9 different aldehydes account for 92.73% of all volatiles.

Though there were no literatures evaluating goat meat volatile profile related to genetic groups, except for hydrocarbons, breed differences on all classes of volatile compounds have been reported in lambs (ELMORE et al., 2000). However, for beef there were differences only in some volatiles (ELMORE et al., 2004).

The effect of genetic group on goat meat volatile profile can also be observed according to the number of volatiles identified. In this respect, the volatile profile from animals of ½ Moxotó + ½ Bôer, followed by ½ Boer + ½ SRD, genetic groups presented greater number of different volatile compounds. In these genetic groups, respectively, 37 and 32 different types of volatile compounds were identified. These numbers are lower than those (53-54) reported by MADRUGA et al. (2002) in the volatile of mixed breed (Creole X Anglo Nubian, Saanen or English Alpine) intact male goats slaughtered between 175 and 220 days of age and also indicate flavor differences due to genetic groups. These differences in volatile profiles are probably related to the observed (data not shown) genotype differences in fatty acid composition.

Conclusions

Genetic group affect goat meat flavor and may be related to differences in fatty acid profiles. Under the experimental conditions genetic group having Bôer blood presented a greater number of volatiles, especially aldehydes, alcohols, hydrocarbons and ketones.

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Tables and Figures

Table 1 – Meat volatile compounds from intact male goat genotypes and their relative proportion.

Volatile Compounds and class	Identification form *	LRI	½ Boer + ½SRD	½Savanna + ½SRD	½Moxotó + ½Boer	½Kalahari + ½SRD	½ Anglo Nubian +½SRD
Aldehydes (14)							
3-methyl butanal	A,C,E,F	643	0,05	Nd	1,70	Nd	Nd
2- methyl butanal	A,C,E,F	655	Nd	1,40	0,60	Nd	Nd
Hexanal	A,C,D,E,F	800	3,76	17,79	6,09	9,19	Nd
Heptanal	A,B,C,D,E,F	901	0,82	Nd	3,28	Nd	Nd
Benzaldehyde	A,C,E	959	0,85	Nd	1,82	1,06	Nd
Octanal	A,B,C,D,E,F	1002	0,52	0,75	2,44	Nd	Nd
Nonanal	A,B,C,D,E,F	1103	1,49	4,43	4,98	5,76	Nd
2-nonenal	A,D,E,F	1160	Nd	Nd	0,43	Nd	Nd
2-decenal	A,C,D,F	1262	Nd	Nd	0,50	Nd	Nd
Trans-2-undecanal	A,D,E	1364	Nd	Nd	0,38	Nd	Nd
Tetradecanal	A,D,E,F	1612	0,21	Nd	0,19	Nd	Nd
Hexadecanal	A,B,C,D,E,F	1817	9,25	9,27	22,48	18,69	61,00
9-octadecenal	A,D	1997	Nd	Nd	0,31	Nd	Nd
Octadecanal	A,D	2021	0,64	Nd	3,40	Nd	2,65
Relative area (%)			**17,59**	**33,64**	**49,29**	**34,70**	**63,65**
Alcohols (10)							
Trimethyl nonanol	A	667	Nd	1,49	Nd	Nd	Nd
Pentanol-2	A,B	701	19,89	1,00	4,62	2,22	2,65
3-methyl 2-heptanol	A	704	4,77	Nd	1,56	Nd	Nd
3- methyl 2-butanol	A	711	0,67	Nd	0,69	Nd	Nd
1-hexenol-3	A,B	852	2,52	Nd	2,68	Nd	Nd
1-hexanol	A,B,F	854	7,21	Nd	8,91	Nd	Nd
1-octenol-3	A,D,E,F	980	0,49	Nd	0,84	Nd	Nd
1-octanol	A,D,E,F	1073	Nd	Nd	0,31	Nd	Nd

Pentadecanol	A,D	1714	0,26	Nd	0,50	Nd	Nd
Hexadecanol	A,D	1882	Nd	Nd	0,12	Nd	Nd
Relative area (%)			**35,81**	**2,49**	**20,25**	**2,23**	**2,65**
Hydrocarbons (9)							
Cycloheptane	A,D	629	Nd	Nd	Nd	2,02	Nd
Tridecane	A,F	1300	0,10	Nd	Nd	Nd	Nd
Tetradecane	A,B,C,D,E,F	1400	0,26	Nd	Nd	Nd	Nd
Pentadecane	A,D,E,F	1485	0,26	Nd	Nd	Nd	Nd
2- methyl Pentadecane	A	1500	Nd	Nd	0,31	Nd	Nd
Hexadecane	A,D,F	1600	0,23	Nd	0,12	Nd	Nd
Heptadecane	A,B,C,D,E,F	1699	Nd	Nd	0,43	Nd	Nd
Octadecane	A,D,F	1800	0,28	Nd	Nd	Nd	Nd
Nonadecane	A,B,D,E,F	1890	0,15	Nd	0,41	Nd	Nd
Relative area (%)			**1,29**	**0**	**1,27**	**2,02**	**0**
Ketones (7)							
2,3-pentanedione	A,E,F	681	Nd	Nd	0,10	Nd	Nd
2-pentanone	A,B,E,F	690	2,06	Nd	2,52	1,97	Nd
3-methyl-2-pentanone	A	697	1,93	Nd	Nd	9,34	Nd
2,3-hexanedione	A	778	0,10	1,25	Nd	Nd	Nd
2-undecanone	A,D,F	1294	Nd	Nd	0,17	Nd	Nd
6,10-dimethyl-5,9-undecadien-2-one	A,C	1452	0,26	Nd	Nd	Nd	Nd
2-tridecanone	A,D,E	1496	Nd	Nd	0,24	Nd	Nd
Relative area (%)			**4,35**	**1,25**	**3,02**	**11,31**	**0**
Esters(5)							
1,1-dodecanodiol diacetate	A	658	Nd	2,84	0,10	Nd	Nd
Butyl acetate	A	825	Nd	Nd	Nd	1,87	Nd
3-methyl butanoate butylate	A	1092	0,46	Nd	0,07	Nd	Nd
Isopropyl Pentanate	A	1126	Nd	Nd	Nd	2,73	Nd
Di methyl Carbamoditianate	A	1379	1,29	Nd	Nd	Nd	Nd
Relative area (%)			**1,75**	**2,84**	**0,17**	**4,60**	**0**

Furanes (2)							
Furfural	A,E,F	829	Nd	Nd	Nd	5,91	Nd
2-pentyl-furane	A,C,D,F	991	0,13	3,69	0,84	Nd	Nd
Relative area (%)			**0,13**	**3,69**	**0,84**	**5,91**	**0**
Aromatics (2)							
Toluene	A,C,D	769	0,62	2,79	0,50	Nd	Nd
Butylated hidroxytoluene (BHT)	A,C	1514	38,36	53,31	24,54	37,78	33,71
Relative area (%)			**38,97**	**56,10**	**25,04**	**37,78**	**33,71**
Terpenoids (2)							
α-terpineol	A	1194	0,10	Nd	Nd	1,46	Nd
α-copaene	A	1919	Nd	Nd	0,12	Nd	Nd
Relative area (%)			**0,10**	**0**	**0,12**	**1,46**	**0**

LRI – Linear Retention Index

[1]ID: identification comparing mass spectra (A – MS);

Literature LRI

B – Jennings e Shibamoyo (1980);

C – Kondjoyan e Berdagué (1996);

D – Madruga (2000);

E – Madruga *et al*. (1997);

F – Sutherland & Ames (1995).