Study on Some Qualitative Features of Meat from Young Goat of Bulgarian Breeds and Crossbreeds of Goats Slaughtered at Various Ages

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ABSTRACT : A comparative study on the quality of meat from three breeds of goats reared in Bulgaria: Local Aboriginal (LA); Bulgarian White Dairy (BWD) and crossbreeds of local aboriginal with Saanen goats (LA × S). Eight intact young male goats from each breed have been included in the experiment. The animals from the three breeds have been reared under similar conditions. The animals have been slaughtered at the age of 2 months (at weaning) and at the age of 6 months (upon reaching sexual maturity). The following tests have been performed on samples of m. longissimus dorsi between 5th and 6th ribs: pH 45 min post mortum, colorimetrically color of meat, water holding capacity and fatty acid composition of the fat. The thickness of muscle fibre and the proportion of muscle, connective and adipose tissue have been microscopically determined at m. longissimus dorsi, m. semitendinosus and m. iliopsoas. After deboning and separating the bigger tendons, the chemical composition of the meat from the left half of the carcass has been determined. The results reveal lack of statistically significant differences among the three breeds concerning pH, the water holding capacity, color of meat, thickness of the muscle fibre and fatty acid composition of the fat. The carcass meat of crossbreeds of LA × S contains significantly more fat than the other two breeds. This influences the proportion of muscle, connective and adipose tissue in m. longissimus dorsi, m. semitendinosus and m. iliopsoas, resulting in more adipose tissue in the LA × S compared to young goats of the LA or the BWD. There are differences in slaughtering 2-month-old goats (at weaning) and 6-month-old ones (upon reaching sexual maturity). At a greater age the content of fat in the carcass increases, as well as the quantity of the adipose tissue, the intensity of the colour of the meat and there is a tendency towards thickening of the muscle fibre and increasing the water holding capacity of meat. The moisture content in meat decreases due to the increase of fat. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 2 : 283-289)***

Key Words : Goats, Meat, Ph, Water Holding Capacity, Color, Thickness of the Muscle Fibre, Proportion of Tissues, Adipose Acids

INTRODUCTION

In the past decade the number of goats in Bulgaria grows rapidly, from 433.000 in 1990 to 1,046.000 in 2000 (SAPI, 2000). That leads to an increase in the share of goat meat in the menu of people in this country, and the interest towards its quality.

In other countries there is also a tendency towards rapid increase in the demand of goat meat (Devendra, 1990; Gipson, 1998; Pagot, 1992).

Goat meat has good nutrition qualities and is slightly different from sheep meat (Melton, 1990; Stankov et al., 1998). Meat of young goats is valued highly, especially so called "white meat", which is a dietary and delicatessen food (Bereza, 1991).

Young goats have relatively good meat-yield characteristics (Orehov, 1974; Tronchev, 1974; Harricharan et al., 1987; Zunev, 1994; Zunev and Uzunov, 1994; Sechin et al., 1995; Galbraith and Berry, 1994; Stankov, 1997; Stankov et al., 1998).

The interest in goat meat is enhanced by the fact that goats deposit less fat in their muscles and hypodermic part than sheep do (Kieton, 1988; Van Niekerk and Casey, 1988; Colomber-Rocher et al., 1992). That presupposes the yield of lean meat which is an important for reducing cardiovascular diseases.

However, information about the qualitative features of the meat from young goats is still scarce.

Meat quality and taste are determined to a large extend by the quantity and fatty acid composition of fats (Melton, 1990). In that respect there are data concerning some breed variations. Nitsan et al., (1987) data reveal lower level of saturated fatty acids and higher level of monounsaturated fatty acids in Saanen young goats compared to Potchoila et al. (1990) data about the Alpine breed. The local goats in Florida are characterized by a low proportion of the polyunsaturated fatty acids to the saturated ones (Johnson et al., 1995). Park and Washington (1993) have recorded differences in the fatty acid composition of fats of Alpine and Nubian goats reared under equal conditions.

Meat quality is determined to a large extent by its morphological structure (Petrov, 1971, 1982). There are very few studies on the various goat breeds in that area.

The recorded differences in meat composition in the various goat breeds aroused our interest in a comparative study of meat quality in breeds reared in this country.

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The objective of the present study is to record some breed peculiarities concerning the chemical composition, including the fatty acid content as well as some morphological and physical and chemical parameters about meat quality of two goat breeds reared in Bulgaria and their crossbreeds.

MATERIALS AND METHODS

A total of 24 intact male young goats have been included in the study-8 of them from the local aboriginal breed, 8 from the Bulgarian White Dairy breed and 8 F_1 crossbreeds of local goats (females) with thoroughbred Saanen bucks. The experiment has been carried out on a private goat farm in the town of Aitos. The goats from the different breeds have been reared in one herd which means-under equal conditions and equal nutrition.

Young goats have been slaughtered at two age levels-2 months, at weaning and 6 months, upon reaching sexual maturity. At these two ages 4 young goats from each breed and crossbred have been slaughtered.

The pH test, the ones about the quantity of unbound water and color of meat have been carried out on m. longissimus dorsi between the 5th and 6th rib at the ages of 2 and 6 months by Gran-Hamm's methods, modified by Pinkas (1973).

Meat pH has been measured by a combined glass electrode to a portable pH-meter Seibold on m. longissimus dorsi between the 5th and 6th rib, 45 minutes post mortum. The measuring was performed at three spots on each sample and the results were presented as average figures.

Meat color was determined on a 2-centimeter thick slice made perpendicularly on the muscle fibre of samples 24 h post mortum and 2 h after cutting the sample. We recorded the color by a remission attachment Rd/O to a spectrocolorimeter SPECOL, equipped with a ZV attachment at a wave length of 525 nm against a white standard of magnesium carbonate.

The water holding capacity was recorded as a percentage of the total water quantity determined by drying 5 g of minced meat from m. longissimus dorsi according to the method described in AOAC (1984).

The chemical composition after the Weende method (AOAC, 1984) has been determined after deboning the left half of the cooled carcass. In that process the inner detachable fat around the pelvis and kidneys and the large tendons have been removed. The obtained soft tissue (meat) have been minced separately for each animal through a meat-minced with openings of 1.2 cm, mixed and minced again through a openings of 0.3 mm. After that the meat has been mixed and minced once again for obtaining homogeneous mixture.

The content of fat has been determined by an petroleum ether extraction of 5 g of meat on Soxhlet's apparatus, of protein by the amount of nitrogen, established by Kjeldahl's method (N × 6.25) and of the mineral substances - by burning the sample to complete turning to ashes pursuant to the instructions in AOAC (1984).

For testing the proportion between the tissue components and the diameter of the muscle fibre the following samples have been taken: from m. longissimus dorsi at the last rib; from m. iliopsoas at the 6th lumbar vertebra and from the m. semitendinosus. The taken samples have been fixed and then dipped in gelatin and paraffin and dissected transversely and longitudinally along the muscle fibre on a gliding microtom. The 8 μm-thick cuts have been colored with Sudan III and hematoxillin (Petrov, 1971).

The relationship among the structural elements in the muscles - muscle fibre, connective and adipose tissue, has been quantitatively determined. For that purpose the area of the dissected primary muscle fascicles, the connective tissue among them (the perimysium) and the adipose tissue has been recorded by an integration table "ISA" on an area of 1 cm^2. For determining the diameter of the muscle fibre we adopted the method employed by Petrov (1971). The average dissected area of the muscle fibre has been determined by a drawing device and a planimetric weight method. About 80 to 100 muscle fibres have been measured from a sample. The tests have been carried out at the Meat Laboratory and at the Central Research Laboratory of the Agricultural Faculty, Thracian University.

The fatty acid composition has been determined on a sample of minced and homogeneously mixed meat from m. longissimus dorsi. The extraction and removal of lipids have been performed according to the procedure described by Bligh and Dyer (1959). The dissolving agent has been removed by a rotating vacuum evaporator and after the the sample has been saturated with nitrogen. Part of the refined sample has been dissolved in chloroform for chromatographic purposes and methyl processed with BF_3 in methanol. The separation of the fatty acids has been performed on a gas chromatograph Pay Unicam 304 equipped with a flame-ionizing detector. A glass column of 2 mm inner diameter and 2 m long has been used, filled with 10% butanediol succinate (BOS) applied on 60-80 mesh chromosorb W. The samples have been chromatographied fixed with gas carries nitrogen 8 ml/min, temperature programmed from 180 to 230°C.

The amount of the eliminated fatty acids has been determined by an integrator.

The test results have been statistically processed by the software Statistica for Windows, Release 4.3 (Stat. Soft. Inc., 1994).

RESULTS AND DISCUSSION

pH, water holding capacity and color of meat

Some of the basic qualitative parameters of meat - pH, water holding capacity and color of meat - have been introduced in table 1.

As far as pH of meat is concerned, the differences among the groups are insignificant ($p>0.05$). The data prove that the reaction is acid and that is normal after the slaughter of animals when pH drops below 7. The recorded pH values at both slaughtering ages are within the limits of normal values, i. e. close to the isoelectric point at which myosin is associated to the actin, in the actomyosin complex and the post mortum stupor (rigor mortis) takes place.

The high water holding capacity of meat, over 35% accounts, for its good quality. The data reveal that for all studies breeds upon slaughtering at the age of 2 months when young goats are weaned, the water holding capacity has lower values compared to the ones when slaughtering takes place at the age of 6 months. The differences, however, are insignificant ($p<0.05$).

The differences in the colour of meat among the three studied breeds are insignificant ($p<0.05$). In all studied breeds at the age of 6 months the colour of meat tends to be more intensive than that at the age of 2 months which shows that the quantity of myoglobin increases and that decreases meat quality to a certain extent.

Proportion of tissues in the muscles

As is normally to be expected, the content of the adipose tissue is considerably increased in all muscles as age advances. Of course, that results in slight and insignificant reduction of the relative share of muscular and connective tissues in muscles. The proportion muscle to connective tissue doesn't change significantly with age (table 2).

The most significant difference among the three tested breeds is in the adipose tissue content. The Bulgarian White Dairy (BDW) breed has considerably more adipose tissue than the local aboriginal goats and the Saanen crossbreeds (LA × S), which is more prominent at a 6-month age (table 2).

Young goats from local breeds have significantly less adipose tissue in the muscles compared to the ones from the other breeds. This can be attributed to the low milk production of the breed, which has obviously provided a lower level of nutrition of those young goats and their growth capacity. Especially during the suckling period which in this case is 2 month, the young goats from breeds of higher milk yield (BWD and LA × S) passes more adipose tissue than the breeds of lower milk yield (LA). At the age of 6 months, quickly growing young goats of the bigger breeds (LA × S) have less adipose tissue than the smaller ones of the local aboriginal goats.

It is obvious that the change in the proportion of tissues depends mostly on the amount of adipose tissue. When it grows, the share of the muscle and the connective tissue decreases.

There is a weak tendency towards increasing the share of connective tissue with increasing the adipose tissue, which are morphologically interrelated.

The data that have been obtained reveal higher values of muscle tissue content and lower ones of connective and adipose tissue content compared to the data about local young goats, published by Stankov et al. (1998).

Thickness of muscle fibres

The results from the study of the thickness of muscle fibre of m. longissimus dorsi, m. iliopsoas and m. semitendinous have been presented in table 3. Both at a age of 2 months (at weaning), and at the age of 6 months local young goats are characterized by the thinnest muscle fibre of the three examined muscles. The differences are

Table 1. Quality meat parameters* (means from 12 determinations of 4 animals for each breed)

Parameters	Local aboriginal		Bulgarian white dairy		Crosbred F1 (Local×Saanen)	
	X ± SE	CV	X ± SE	CV	X ± SE	CV
At 2 months						
pH	5.42±0.10	3.69	5.61±0.16	5.70	5.68±0.15	5.28
Water holding capacity, %	36.64±1.14	6.22	35.29±1.09	6.18	36.88±1.42	7.70
Meat color, extintion or absorbtion at 525 nm	23.03±0.71	6.17	22.5±0.64	5.67	22.75±0.80	7.03
At 6 months						
pH	5.72±0.24	8.39	5.38±0.18	6.69	6.02±0.21	6.98
Water holding capacity, %	38.78±1.43	7.37	37.84±1.29	6.82	39.10±1.47	7.52
Meat color, extintion or absorbtion at 525 nm	23.24±0.89	7.66	23.40±0.74	6.32	23.31±0.76	6.52

* The differences between breeds and two ages are insignificant at $p<0.05$.

Table 2. Proportion of tissue components, in % (means from 12 samples for each breed)

Parameters	Local aboriginal		Bulgarian white dairy		Crosbred F1 (Local × Saanen)	
	X ± SE	CV	X ± SE	CV	X ± SE	CV
At 2 months:						
m. longissimus dorsi						
Muscle tissue	94.93±5.20[a]	10.96	93.63±4.73[a]	10.10	95.07±4.53[a]	9.53
Connective tissue	4.06±0.31[ab]	15.27	4.50±0.38[a]	16.89	3.42±0.19[b]	11.11
Adipose tissue	1.01±0.10	19.80	1.87±0.17[a]	18.18	1.51±0.08[a]	10.60
m. semitendinosus						
Muscle tissue	94.41±5.68[a]	12.03	93.75±4.10[a]	8.75	94.96±4.62[a]	9.73
Connective tissue	4.76±0.31[a]	13.03	4.94±0.32[a]	12.96	3.81±0.20	10.50
Adipose tissue	0.83±0.07	16.87	1.37±0.10[a]	14.60	1.23±0.07[a]	11.38
m. iliopsoas						
Muscle tissue	95.38±5.24[a]	10.99	94.53±4.28[a]	9.06	95.21±4.77[a]	10.02
Connective tissue	3.56±0.22[a]	12.35	3.85±0.20[a]	10.39	3.67±0.20[a]	10.90
Adipose tissue	1.06±0.07[a]	13.21	1.62±0.10	12.34	1.12±0.06[a]	10.71
At 6 months						
m. longissimus dorsi						
Muscle tissue	93.75±4.01[a]	8.55	92.74±3.39[a]	7.31	94.09±3.45[a]	7.33
Connective ttssue	3.94±0.21[a]	10.66	4.35±0.26[a]	11.95	4.03±0.18[a]	8.93
Adipose tissue	2.31±0.12[a]*	10.39	2.91±0.17[b]*	11.68	1.88±0.07[c]	7.44
m. semitendinosus						
Muscle tissue	94.03±3.98[a]	8.47	92.89±3.58[a]	7.71	94.60±3.46[a]	7.32
Connective tissue	4.38±0.23[a]	10.50	4.44±0.21[a]	9.46	4.16±0.19[a]	9.13
Adipose tissue	1.59±0.09[a]*	11.32	2.67±0.13b*	9.74	1.24±0.06[c]	9.68
m. iliopsoas						
Muscle tissue	94.93±4.20[a]	8.85	93.85±3.86[a]	8.23	95.11±3.97[a]	8.35
Connective tissue	3.54±0.20[a]	11.30	4.18±0.22[b]	10.53	3.72±0.16[ab]	8.60
Adipose tissue	1.53±0.09[a]*	11.76	1.97±0.11[b]*	11.17	1.17±0.05[c]	8.55

[a,b,c] the differences between means within the same line whit various superscripts are significant at p<0.05 level of probability.
* Significant differences (P<0.05) due to the age in one breed are mentioned with star.

significant at p<0.05 at the age of 2 months for the three muscles and at the age of 6 months - only for m. longissimus dorsi. Between the other two breeds there are almost no differences in the diameters of muscle fibre. It is interesting to note that at the age of 6 months in all studies breeds the muscle fibre in all three muscles are considerably (p<0.05) thicker than the ones of young goats at weaning (table 3).

The data reveal that significant age changes take place which results in a rougher muscle structure. Similar changes have been recorded by Petrov (1982) in order animals (cattle, swine, poultry and rabbits). The results of our study point out that young goats at the two studied ages have thinner muscle fibre than cattle, buffaloes, sheep, swine, hens, turkeys and gees and almost the same measure parameters as the white Peking duck (Petrov, 1982)

The small diameters of muscle fibre in the studied breeds of young goats is a prerequisite for good taste qualities and better digestibility of the meat, obtained from young goats.

Chemical composition of meat

Concerning moisture, protein and mineral substance content significant differences among the breeds and crossbreeds of young goats at the two slaughtering ages are not observed (table 4). Significant differences are present in regard to the fat content of meat. The F_1 of Saanen crossbreeds are characterized by the highest content of fat at the age of 2 and 6 months and the differences with the other two breeds are highly significant (p<0.01).

With increasing the age of young goats, the dry matter content increases in all breeds which is provoked by the increased amount of fat in meat (table 4).

As a whole, the water amount in meat is relatively high. That is explained by the young age of slaughtering the goats and the comparatively low degree of fattening.

Fatty acid composition

Statistically relevant differences in the content of various fatty acids have not been recorded in our studies

Table 3. Muscles diameter* (means from 80 to 100 measured fibre for each muscle and breed) (μm)

Parameters	Local aboriginal		Bulgarian white dairy		Crosbred F1 (Local × Saanen)	
	X ± SE	CV	X ± SE	CV	X ± SE	CV
At 2 months						
m. longissimus dorsi	27.95±0.43^{a}	6.88	28.68±0.47^{a}	7.33	28.70±0.54^{a}	8.41
m. semitendinosus	27.04±0.39^{a}	6.45	29.12±0.51^{b}	7.83	29.43±0.50^{b}	7.60
m. iliopsoas	25.13±0.45^{a}	8.01	26.90±0.43^{b}	7.15	26.31±0.42^{ab}	7.14
At 6 months						
m. longissimus dorsi	29.76±0.55^{a}	8.27	31.11±0.58^{ab}	8.34	31.52±0.63^{b}	8.94
m. semitendinosus	30.27±0.53^{a}	7.83	30.97±0.61^{a}	8.81	31.06±0.54^{a}	7.78
m. iliopsoas	28.22±0.47^{a}	7.45	29.64±0.52^{b}	7.85	28.78±0.49^{ab}	7.61

^{a,b} The differences between one and the same age and muscle are significant at $p<0.05$ if they have not common letters.
Differences due to the age are significant at $p<0.05$ at all breed and muscles.

Table 4. Chemical composition of meat from the left half of the carcass, %

Parameters	Local aboriginal		Bulgarian white dairy		Crosbred F1 (Local × Saanen)	
	X ± SE	CV	X ± SE	CV	X ± SE	CV
At 2 months						
Moisture	72.38±3.13^{a}	8.64	73.26±2.84^{a}	7.75	71.92±2.97^{a}	8.26
Protein	18.61±0.45^{a}	4.84	18.15±0.50^{a}	5.51	17.48±0.65^{a}	7.44
Fat	7.94±0.28^{a}	7.05	7.53±0.23^{a}	6.11	9.52±0.34^{b}	7.14
Mineral substances – Ash	1.07±0.04^{a}	7.48	1.06±0.03^{a}	5.66	1.08±0.02^{b}	3.70
At 6 months						
Moisture	70.06±3.08^{a}	8.79	70.70±3.16^{a}	8.94	69.08±3.22^{a}	9.32
Protein	17.92±0.59^{a}	6.58	17.38±0.62^{a}	7.13	16.98±0.57^{a}	6.71
Fat	10.92±0.33^{a}	6.04	10.84±0.37^{a}	6.83	12.86±0.41^{b}	6.38
Mineral substances - Ash	1.10±0.04^{a}	7.27	1.08±0.04^{a}	7.41	1.08±0.03^{a}	5.56

^{a,b} Differences between means at one line are significant ($p<0.05$) if there are different letters

(either among the various breeds in Bulgaria or at the age of 2 and 6 months of the young goats) (table 5).

In the three breeds of young goats there is a tendency towards decrease in the sum of unsaturated fatty acids at the expense of saturated ones with age. As a result the proportion saturated: unsaturated fatty acids becomes narrower.

The palmitic acid content ($C_{16:0}$) is greater and the content of linoleic ($C_{18:2}$) and stearic ($C_{18:0}$) acids is lower in the breeds that we have studied compared to the Alpine and Nubian breeds in Park and Washington's (1993) studies of the same muscle.

Especially great are the differences about the linoleic acid - 9.23% at the Alpine, 11.3% at the Nubian against 3.84 to 4.17% at the Bulgarian breeds. Park and Washington (1993) have not recorded linolenic acid ($C_{18:3}$) whilst we have recorded values from 1.17 to 1.40%. We have not recorded $C_{20:4}$ while Nitsan et al. (1987), Park and Washington (1993), Johnson (1995), Matsouka et al. (1992) and Matsouka et al. (1997) report about 2 to 4.67% of $C_{20:4}$.

There are differences compared to the data published by other authors in the content of $C_{14:1}$, $C_{15:0}$ and $C_{17:0}$ but due to the small quantities of these fatty acids which some authors do not note, it is hardly worth commenting them.

Compared to other ruminants (sheep, cattle), the fatty acid content in m. longissimus dorsi doesn't differ greatly in goats (Rule and Beitz, 1986; Solomon et al., 1991; Marinova et al., 1992; Enser et al., 1998). The differences are of an order which could be accounted for individual differences, age, sex and nutrition (Nitsan et al., 1987; Banskalieva et al., 2000).

CONCLUSIONS

The comparative studies of meat quality in there breeds of young goats reared in Bulgaria do not reveal great differences in pH, water holding capacity, colour of meat, thickness of muscle fibre and fatty acid composition of fats in m. longissimus dorsi.

The carcass meat of crossbreeds of local goats with Saanen bucks contains significantly more fat than the other two breeds. That reflects of the proportion of muscle.

Table 5. Fatty acid content of fat from m. longissimus dorsi, in %*(means of 4 analysis)

Fatty	Local aboriginal		Bulgarian white dairy		Crosbred F1 (Local × Saanen)	
Acids	At 2 months	At 6 months	At 2 months	At 6 months	At 2 months	At 6 months
$C_{14:0}$	2.95±0.09	3.14±0.07	2.77±0.17	3.29±0.06	2.86±0.06	3.15±0.11
$C_{14:1}$	0.30±0.04	0.26±0.06	0.25±0.03	0.31±0.04	0.33±0.05	0.47±0.12
$C_{15:0}$	0.53±0.08	0.79±0.05	0.71±0.08	0.72±0.05	0.55±0.07	0.77±0.09
$C_{16:0}$	26.16±1.14	27.12±1.09	27.08±1.39	28.53±1.11	27.97±1.10	29.30±1.34
$C_{16:1}$	3.84±0.10	3.76±0.11	3.62±0.09	3.48±0.12	3.40±0.15	3.54±0.30
$C_{17:0}$	0.15±0.02	0.17±0.02	0.16±0.02	0.16±0.03	0.19±0.03	0.23±0.02
$C_{18:0}$	14.93±0.56	15.16±0.54	14.64±0.57	15.49±0.66	14.94±0.65	14.98±0.75
$C_{18:1}$	41.67±1.27	41.82±1.35	40.86±1.48	41.26±1.58	40.35±1.38	39.95±1.68
$C_{18:2}$	4.15±0.12	3.97±0.07	3.84±0.09	3.85±0.11	4.17±0.42	4.04±0.45
$C_{18:3}$	1.29±0.11	1.40±0.09	1.23±0.12	1.17±0.08	1.29±0.11	1.33±0.17
Saturated	44.71	46.36	45.36	48.15	46.51	48.43
Monounsaturated	45.81	45.84	44.73	45.05	44.08	43.96
Polyunsaturated	5.44	5.37	5.07	5.02	5.46	5.37
Unsaturated:saturated	1.15	1.10	1.10	1.04	1.07	1.02

* Differences between breeds, depend on of age at one and the same breed are insignificant at $p<0.05$.

connective and adipose tissue in m. longissimus dorsi, m. semitendinosus and m. iliopsoas manifested in more adipose tissue in the crossbreeds compared to young goats of the Local aboriginal and Bulgarian white dairy breeds.

There are differences when slaughtering at the age of 2 months (at weaning) and at the age of 6 months (upon reaching sexual maturity). The content of fat in the carcass, the amount of adipose tissue, the intensity of the colour of the meat increase with age and there is a tendency towards thickening of the muscle fibre and increasing the water holding capacity of meat. The moisture content in meat decreases with the increase of fat.

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