

Study on chemical composition, fatty acid composition and technological quality of meat in Boer goat kids

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Abstract

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The main objectives of this study are to evaluate the chemical composition, fatty acid composition and technological quality of meat in Boer goat kids weaned at 120 days of age for producing “capretto” goat meat. Analyzed were samples from four male single born kids, offsprings of the first Boer goats imported in Bulgaria. The Boer goats were kept in AGROUSTINA FARM in Plovdiv district, which was the first farm in Bulgaria to raise the bloodline Boer goat. The studied kids were raised with their mothers until 120 days of age and their main food was their mother’s milk. Analyzed were several chemicals and technological parameters: moisture %, protein %, fat %, minerals %, pH_{24} , water-holding capacity (WHC), cooking losses at roast (%), losses at keeping (%), tenderness, ($^{\circ}\text{P}$) in the three muscles: m. *Longissimus dorsi* (LD), m. *Semimembranosus* (SM) and m. *Iliapsoas* (Ips). LD had the highest content of moisture (75.26%) and fat (3.19%) but least protein (20.59%) and minerals (0.96). The highest content of protein (22.27%) and minerals (1.30%) had SM. The lowest pH_{24} was in Ips – 5.30 and the highest – in MS 5.62. The lowest WHC were found in LD 22.06% but the highest in Ips – 27.68%. The cooking losses at roast of the three analyzed muscles ranged from 47.66% for SM to 54.75 for Ips. There were large differences between the losses at keeping – from 2.38% for LD to 5.59 for SM. The highest tenderness had Ips (368.26 $^{\circ}\text{P}$) but the lowest had SM (306.74 $^{\circ}\text{P}$). The fatty acid (FA) composition was analyzed in samples from two adipose tissue depots: pelvic fat and kidney fat by gas chromatography. Fatty acid ratios (Ω -6/ Ω -3 and PUFA/SFA ratios) as well as three indexes: the Index of atherogenicity (IA), the Index of thrombogenicity (IT) and the Cholesterolemic index (h/H) were calculated on the basis of individual FA content in kids fat depots. FA composition showed that oleic (C18:1), docosahexaenoic (C22:6 Ω -3) and arachidonic (C20:4 Ω -6) FA comprised the largest proportion of FA, with oleic acid being the most abundant – respectively 39.93% and 38.42%. The poly-unsaturated fatty acid (PUFA) presented the highest percent of FA in both fat depots – 43.87% in pelvic fat and 40.23% in kidney fat; mono-unsaturated fatty acids (MUFA) were higher in kidney fat (43.10%) than in pelvic fat (41.16%). The saturated fatty acid (SFA) percent were only 14.97% and 16.67% respectively. Desirable fatty acids (DFA) were 86.36% in pelvic fat and 85.40% in kidney fat. The value obtained for Ω -6/ Ω -3 FA ratio is 0.908 for pelvic fat and 1.100 for kidney fat that is close to the recommended 1.0 as ideal value. The PUFA/SFA ratio varied from 2.41 in kidney fat to 2.93 in pelvic fat. The values obtained for h/H index were 3.216 in pelvic fat and 2.755 in kidney fat; the average IT was respectively 0.148 and 0.184 and the IA was 0.202 and 0.221 respectively. The all studied FA ratios and indexes were very favorable and indicate healthiness of capretto meat from Boer goat kids weaned at 120 days age.

Keywords: goat meat; chemical composition; technological quality; muscles; fatty acids, lipid indexes

Abbreviations: LD – *musculus Longissimus Dorsi*, SM – *musculus Semimembranosus*, Ips – *musculus Iliapsoas*; SFA – saturated fatty acid, UFA – unsaturated fatty acid; MUFA – mono-unsaturated fatty acid, PUFA – poly-unsaturated fatty acid, DFA – desirable fatty acid

Introduction

Globally, goat meat consumption has increased during the past 20 years (Madrua & Bressan, 2011). Consumers in the Western world do not favor goat meat (Babiker et al., 1990), although the perceptions of Western consumers are changing because of its low fat and cholesterol contents and favorable sensory characteristics (Webb et al., 2005; Madrua & Bressan, 2011). As some authors have pointed (Seregi & Kovacs, 2016), goat meat has a high nutritional value, contributing to an enjoyable and healthy human diet. Goat meat is internationally regarded as a lean red meat with favorable nutritional characteristics (Babiker et al., 1990; Hogg et al., 1992; Webb et al., 2005). Goat meat has a somewhat darker red color, coarser texture and characteristically different flavor and aroma compared with lamb or mutton (Schönfeldt et al., 1993a; Casey et al., 2003; Sheradin et al., 2003b).

Muscle contains the important quality parameters in the nutrient value of meat. Thabalala et al. (2003) reported that composition of Boer kids lean tissue was: 69.4% moisture, 22.8% protein, 10.5% fat and 0.95% ash. Sheradin et al. (2003a) found that increasing days in feedlot (28 days and 58 days) led to changes in composition of Boer kids lean as follows: reducing the moisture (respectively 65.1% and 59.5%) and protein (17.7% and 17.0%) and rise the fat (respectively 13.5% and 21.2%). The kids, crosses with Boer goat, had less fat deposition than kids from dairy breeds and cross-breeds dairy X indigenous breeds (Dhanda et al., 2003).

Yields and properties of individual muscles are important for boneless value-added product manufacture. The shoulder muscles and *Semitendinosus* were lighter in color, the cooking losses were lower for smaller muscles such as the *Biceps brachii* and *Semitendinosus*, and tenderness was higher for *Infraspinatus* and *Longissimus dorsi* (McMillin & Brock, 2004).

The meat pH can be considered one of the most important and basic factors that can affect meat quality. Ultimate pH values (pHu) in goat carcasses generally range between 5.8 and 6.2 (Nuñez Gonzalez et al., 1983; Kannan et al., 2001; Simela et al., 2004a,b). Goat carcasses with a lower pHu have better values of tenderness, lower shear force values and better colorimetric values (Simela et al., 2004a) than those with a high pHu.

Tenderness and juiciness are very important for perception of goat meat and are one of the main characteristic of quality. They decline with the age of goats. Tenderness is influenced by collagen and muscle fibers. Goat meat have collagen content higher, solubility lower, muscle fibrils thicker, and bundles larger than sheep, giving a coarse texture (Webb et al., 2005). Different muscles will have differing amounts

of connective tissue and muscle fiber types that influence tenderness. The *Longissimus dorsi* and *Biceps femoris* muscle were slightly more tender than the *Semimembranosus* and *Adductor* muscles (Johnson et al., 1995). Shear force was less in *Longissimus dorsi* than *Semimembranosus* and *Triceps brachii* (Kannan et al., 2001). Cooking losses from goat meat tend to be high (more than 35%), and this detracts from the sensation of juiciness. Cooking losses contributed at least in part to the perception of consumers that goat meat is less juicy than lamb or mutton (Schönfeldt et al., 1993b; Tshabalala et al., 2003).

Both the chemical and physical properties of fat and fatty acid composition influence the organoleptic properties and keeping quality of meat and have a salient role in nutrition (Webb et al., 2005; Webb & O'Neill, 2008). Ratio between saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids influences the consistency, chemical composition and sensory characteristics of carcass fats and the shelf life of meat products. According to the Harvard School of Public Health (2008), SFA (the bad fats) increase the risk of cardiovascular disease and other chronic diseases, while unsaturated fats MUFA and PUFA (good fats) can improve cholesterol level in blood, alleviate inflammation, stabilize heart rhythm, and have numerous other useful effects. Desirable fatty acids (DFA) are important and include C18:0 and all unsaturated fatty acids (Banskalieva et al., 2000) because they have favourable implications on consumer health. There should be a high concentration of DFA. The PUFA/SFA ratio should be high and be at least 0.45 (Enser et al., 1998). The concentration of DFA and proportions PUFA/SFA have been calculated to be higher in goat meat than in beef and lamb (Webb et al., 2005). Fatty acid content of *Longissimus dorsi thoracis* muscles from Boer and feral Australian male goats were primarily oleic acid (C18:1) 43-54%, palmitic acid (C16:0) 23-28% and stearic acid (C18:0) 11-18%. Increased slaughter weight increased SFA and decreased stearic acid (Werdi Pratiwi et al., 2006). Within PUFA, a high proportion of Ω -3 fatty acids is beneficial while the ratio of Ω -6/ Ω -3 of less than 5 is acceptable and that is close to 1 is considered as ideal (Raes et al., 2004). High Ω -6 PUFA content is undesirable because these fatty acids yield eicosanoids with more powerful thrombotic tendencies than Ω -3 PUFA derivatives, and would therefore predispose consumers to coronary diseases (Enser, 2000).

Goat meat has an advantageous and salubrious fatty acid profile, and the meat is ideal for health-conscious consumers (Hogg et al., 1992; Mahgoub et al., 2002). Desirable fatty acids in goat meat ranged between 61 and 80% (Banskalieva et al., 2000), while figures were 67.45% for Omani goats

(Mahgoub et al., 2002) and 65.37 and 66.4% for Boer and South African indigenous goats, respectively (Tshabalala et al., 2003) and an average of 74% for Boer goats (Sheradin et al., 2003a). The PUFA/SFA ratios of goat meat are often greater than similar values for lamb/mutton, beef, and pork. Banskalieva et al. (2000) show that the PUFA/SFA ratio for different muscles ranged between 0.16 and 0.49 for goat meat (median 0.32). The ranges (median) for lamb/mutton and beef were, respectively, 0.07-0.26 (0.19) and 0.11-0.40 (0.25).

The cholesterol content of goat meat generally varies between 30 and 60 mg/100 g (Werdi Pratiwi et al., 2006) and that is least of all other types of meat – 73.1 in beef and pork, 76.0 in chicken and 78.2 in lamb (USDA, 2001). The clinical studies show that unsaturated fatty acids can help reduce LDL (called bad cholesterol) and increase levels of HDL (called good cholesterol) in the blood. Based on these things, it can be argued that goat meat helps reduce blood cholesterol levels and thereby reduce the risk of atherosclerosis and coronary disease (Correa, 2011).

One PUFA with anti-atherogenic properties are the linoleic acid (C18:2 Ω -6), while docosahexaenoic (C22:6 Ω -3) acids possess anti-thrombogenic effects (Badimon et al., 2010). Some authors (Ivanova & Hadzhinikolowa, 2015) suggest that the Ω -6/ Ω -3 fatty acid ratio could be a reliable parameter for evaluation of the relative nutritional value of lipids, whereas their functional properties could be assessed through primary lipid indices as atherogenic index (IA), thrombogenic index (IT) and cholesterolemic index (h/H), calculated on the basis of fatty acids content.

There are several investigations on chemical composition and technological quality as well as fatty acid composition of meat in local indigenous goat breeds and some dairy goat breeds in Bulgaria (Raychev & Stankov, 1986; Vuchkov, 2009, 2020). There are no studies on these important characteristics for quality and healthiness of meat in Boer goat kids in Bulgaria.

The main objectives of this study are to evaluate the chemical composition, fatty acid composition and technological quality of meat in Boer goat kids weaned at 120 days of age for producing “capretto” goat meat.

Material and Methods

In order to achieve the aim of the study were used four male single born kids, offsprings of the first Boer goats imported from Austria. The goats were kept in AGROUSTINA FARM in Plovdiv district, which was the first farm in Bulgaria to raise the bloodline Boer goat. The studied kids were raised with their mothers until 120 days of age. Their main food

until reaching that age was their mother’s milk, and a week after their birth they had free access to pelleted concentrates (with 18% crude protein), lucerne and meadow hay.

After reaching 120 days of age, immediately after weaning, the kids were taken to a certified abattoir with licensed transport and following the requirements for animal welfare during transport. In the slaughterhouse after 18 h rest and deprivation of solids but with free access to water, the kids were slaughtered and the carcasses were investigated. The carcasses were placed in a chiller at 2-4°C for 24 h, after that were taken samples from the following three muscles: *Musculus Longissimus dorsi* (LD), *Musculus Semimembranosus* (SM) and *Musculus Iliopsoas* (Ips) for evaluation of chemical composition and technological quality of each muscle. The samples were analyzed in Meat Laboratory at Faculty of Agriculture and in Central Research Laboratory at Trakia University – Stara Zagora.

There were analyzed several physico – chemicals parameters using the following methods:

- Moisture content was determined according (Bulgarian State Standard) BSS 5712:1974;
- Protein content was determined according BSS 9374:1982;
- Fat content was determined according BSS 8549:1992;
- Minerals content was determined according ISO 936:1998
- The ultimate pH (pH_{24} , measured at 24 h after slaughter) was determined using Testo 205 pH meter by insertion of the electrode into the each of muscles (LD, SM and Ips) on the chilled carcass;
- Water-holding capacity (WHC) was determined using the classic method of Grau & Hamm (1953), described by Zahariev & Pinkas (1979);
- Cooking losses at roast (%) was determined as difference in weight of sample before and after cooking (in percent). Samples of each studied muscles (LD, SM and Ips) were weighed, roasted in an oven with compulsion convection at temperature 150° C for 20 min. Samples were then cooled and reweighed;
- Losses at keeping (%) – the samples from the three muscles (LD, SM and Ips) were weighed by electronic scales and after that were put into vacuum bags. After packing the samples were frozen at -18°C for period of 72 hours. After that period the samples were de-frosted at 4°C and were weighed again.
- Tenderness, (°P) was determined using penetrometer DSD VEB Feinmess (Dresden, Germany). The principle of the method is based on the distance penetrated by the needle into a meat sample, under the weight of the screw with the needle, which in this tool is 103.3 g. The tenderness values

were measured in penetration degrees ($^{\circ}\text{P}$), where $1^{\circ}\text{P} = 0.1$ mm. Studied were the three muscles MD, SM and Ips at the 24^h post mortem.

The fatty acid composition was analyzed in samples from two adipose tissue depots: pelvic fat and kidney fat. The fatty acid composition was analyzed by gas chromatography using a “Perkin Elmer model Clarus 500” gas chromatograph and was carried out in Central Research Laboratory at Trakia University. The C18:1 isomers are reported as one value, as this column incompletely resolves them, and we cannot exclude some minor contamination with other C18:1 isomers. All fatty acid results are presented in weight percentages (weight%) of total fatty acid assuming direct proportionality between peak area and fatty acid methylester weight.

Fatty acid ratios: the Ω -6/ Ω -3 fatty acid ratio; the PUFA/ SFA ratio were calculated on the basis of individual fatty acid content in kids fat depots.

The Index of atherogenicity (IA) and the Index of thrombogenicity (IT) were calculated on the basis of individual fatty acid content in kids fat depots using the equations of Ulbricht & Sauthgate (1991):

$$\text{IA} = (\text{C12:0} + 4 \times \text{C14:0} + \text{C16:0}) / \Sigma\text{MUFA} + \Sigma\Omega\text{-6} + \Sigma\Omega\text{-3}$$

$$\text{IT} = (\text{C14:0} + \text{C16:0} + \text{C18:0}) / 0.5 \times \Sigma\text{MUFA} + 0.5 \times \Sigma\Omega\text{-6} + 3 \times \Sigma\Omega\text{-3} + \Sigma\Omega\text{-3} / \Omega\text{-6}$$

The Cholesterolemic index (h/H) is ratio hypocholesterolaemic/ hypercholesterolaemic. The h/H was calculated using the equations of Santos-Silva et al. (2002):

$$\text{h/H} = (\text{C18:1}_{\text{cis-9}} + \text{C18:2 } \Omega\text{-6} + \text{C20:4 } \Omega\text{-6} + \text{C18:3 } \Omega\text{-3} + \text{C20:5 } \Omega\text{-3} + \text{C22:5 } \Omega\text{-3} + \text{C22:6 } \Omega\text{-3}) / (\text{C14:0} + \text{C16:0})$$

All received results from the conducted studies were analysed with the program STATISTICA for Windows.

Results and Discussion

On Table 1 are presented the results from the study on proximate chemical composition measured on three muscles (LD, SM and Ips) in Boer goat kids, weaned at 120 days of age. Water has influence on the quality of the meat, especially the juiciness, but also on the so-called technological quality, and has positive effect on palatability because most of the components of the taste are water soluble (Priolo et al., 2001; Jeremiah et al., 2003). The moisture content ranges in very close limits from 75.26% for LD to 73.89% for SM. The amount of total lipids are low in the three muscles and range from 2.46% for Ips to 3.19% for LD. MS had the highest protein (22.27%) and minerals (1.30%).

Table 1. Chemical composition measured on muscles *Longissimus dorsi* (LD), *Semimembranosus* (SM) and *Iliapsoas* (Ips) in Boer goat kids

Traits	x ± Sx
Moisture, %	
– <i>m. Longissimus dorsi</i>	75.26 ± 0.288
– <i>m. Semimembranosus</i>	73.89 ± 0.415
– <i>m. Iliapsoas</i>	74.41 ± 0.067
Total lipids (fat), %	
– <i>m. Longissimus dorsi</i>	3.19 ± 0.346
– <i>m. Semimembranosus</i>	2.54 ± 0.221
– <i>m. Iliapsoas</i>	2.46 ± 0.048
Protein, %	
– <i>m. Longissimus dorsi</i>	20.59 ± 0.377
– <i>m. Semimembranosus</i>	22.27 ± 0.498
– <i>m. Iliapsoas</i>	21.96 ± 0.140
Minerals, %	
– <i>m. Longissimus dorsi</i>	0.96 ± 0.180
– <i>m. Semimembranosus</i>	1.30 ± 0.215
– <i>m. Iliapsoas</i>	1.15 ± 0.102

In *m. Longissimus dorsi* of kids from the Bulgarian screw-horned longhaired goat weaned at 90 days were determined similar results: moisture 73.7%, protein 23.01%, fat 2.26% and minerals 0.97 (Vuchkov, 2020). The received results in our study for the protein content are similar to some other authors (Thabalala et al., 2003; Sheradin et al., 2003a) that reported in lean of Boer kids and Boer crosses 17.7–22.8%. The values for moisture in our study were much higher than the reported by the same authors – 65.1 to 69.4% and the fat was much lower than reported – 10.5 – 13.5%. The main reason is the low age and slaughter weight of Boer kids in the present study and the fact that they are suckling (without any fattening).

Comparing the meat yield characteristics of kids at different ages from various goat breeds, many authors determined a similar tendency (Pena et al., 2009; Mohammad et al., 2010; Moawad et al., 2013) for the higher moisture and protein content in the meat of the youngest animals. Increasing the slaughter age decreases the percentage of the moisture and protein content, while increasing the fat content.

We can generalize that capretto meat from Boer kids weaned at 120 day of age has high moisture and protein content and less fat content and contribute to healthy human diet.

Ultimate pH of muscles can be considered one of the most important and basic factors that can affect meat quality that were determined by run out of a glycogen and transformed it to lactic acid after slaughter (Santos et al., 2018). The accumulation of lactic acid results in a decline of pH from the live animal at 7.2 to 5.5 in meat (Lawrie, 1992).

Very close pH_{24} values of the three studied muscles (LD, SM and Ips) were found in our investigation (Table 2). The lowest pH_{24} was in *m. Iliapsoas* (5.30) and the highest – in *m. Semimembranosus* (5.62) but the differences were not significant. Slightly higher results for *m. Semimembranosus* pH_{24} were reported by Maynard (2015) – 5.8 and higher by Kannan et al. (2001) – 6.07. According Kannan et al. (2001) there were differences between muscles as a direct result of the differences in proportion of white to red fibers among muscles.

Table 2. Technological quality measured on muscles *Longissimus dorsi* (LD), *Semimembranosus* (SM) and *Iliapsoas* (Ips) in Boer goat kids

Traits	x ± Sx
pH_{24}	
– <i>m. Longissimus dorsi</i>	5.45 ± 0.115
– <i>m. Semimembranosus</i>	5.62 ± 0.169
– <i>m. Iliapsoas</i>	5.30 ± 0.043
Water holding capacity (WHC), %	
– <i>m. Longissimus dorsi</i>	22.06 ± 1.828
– <i>m. Semimembranosus</i>	25.27 ± 0.847
– <i>m. Iliapsoas</i>	27.68 ± 1.531
Cooking losses, %	
– <i>m. Longissimus dorsi</i>	49.05 ± 1.730
– <i>m. Semimembranosus</i>	47.66 ± 1.804
– <i>m. Iliapsoas</i>	54.75 ± 1.013
Losses at keeping, %	
– <i>m. Longissimus dorsi</i>	2.38 ± 0.546
– <i>m. Semimembranosus</i>	5.59 ± 1.933
– <i>m. Iliapsoas</i>	5.14 ± 1.016
Tenderness, °P*	
– <i>m. Longissimus dorsi</i>	324.60 ± 16.738
– <i>m. Semimembranosus</i>	306.74 ± 12.547
– <i>m. Iliapsoas</i>	368.26 ± 10.280

*P – penetration degrees

Water holding capacity (WHC) is the ability of meat to retain its water during application of external force. WHC is an important quality attribute of meat since many physical properties of both raw and cooked meat such as texture, juiciness and consumer acceptance partially dependent upon it and finally influences the final weight of the product.

The lowest WHC (Table 2) was found in *m. LD* – 22.06% but the highest in *m. Ips* – 27.68% with significant differences ($P < 0.001$). Some other authors published that WHC differs between muscles of the same carcass (Hunt & Hedrick, 1977) but Apata et al. (2016) found that WHC in *m. LD* is higher than *m. SM* which was opposite to our results.

Cooking losses from goat meat are of interest because, while the water in the cooked product is the major contributor to the sensation of juiciness (Forrest et al., 1975), cooking losses are often over 35% (Babiker et al., 1990; Dhanda et al., 1999).

The cooking losses at roast of the three analyzed muscles (Table 2) ranged from 47.66% for *m. SM* to 54.75 for *m. Ips* ($P < 0.001$). These values were much lower than published (Ding et al., 2010) in *m. Longissimus thoracis* for Guanzhong dairy goat kids (62.04%) and for several crosses with Boer breed: from 60.95% for F1 to 61.93% for F3. According Offer & Knight (1988) cooking losses are due to denaturation of proteins, which results in structural changes that cause fluid to be expelled. The limited fat content of goat meat possibly exacerbates cooking losses (Lawrie, 1998). We assumed that is one of the reasons for differences between our results for Boer goat kids weaned at 120 days of age and the pointed figures for kids above 180 days of age with period of fattening with more fat content (3.71-4.46%) and higher pH_{24} (6.29 – 6.38).

There were large differences between the losses at keeping of the three studied muscles – from 2.38% for *m. LD* to 5.59 for *m. SM* ($P < 0.001$).

The tenderness was the main factor for the meat eating quality and one of the most important traits which influence palatability and taste characteristics according to consumers (Chulayo & Muchenje, 2013; Sirin et al., 2017; Muhtar et al., 2018). The mean tenderness of the three muscles (LD, SM and Ips) in Boer goat kids weaned at 120 days of age (Table 2) differed significantly ($P < 0.001$). The highest tenderness had Ips (368.26°P) but the least value had SM (306.74°P). The differences in tenderness of goat meat can be due to breed, age and muscles (Lawrie, 1992). Marichal et al. (2003) observed that tenderness in the LD and SM was higher in kids with slaughter weight 6 kg than those with 25 kg. A significant decrease in muscle tenderness was observed (Dhanda et al., 2003) from Capretto to Chevon meat. Some breeds contain less collagen in the muscle and therefore have more tender meat, as is the case of Angora goats producing more tender meat than Boer goats (Kadim & Mahgoub, 2012). Dhanda et al. (2003) showed that meat from Boer crosses kids had higher tenderness and better sensory scores (from panelist taste) compared to other breeds and genotypes.

On Table 3 are presented the results from the study on lipids content and fatty acid composition of total lipids in pelvic fat and kidney fat in Boer goat kids, weaned at 120 days of age. The lipids content was higher in kidney fat (79.42%) than in pelvic fat (71.52%).

Goats deposit more internal fat and less subcutaneous and intramuscular fat compared with sheep and other rumi-

Table 3. Fatty acid composition (%) of total lipids in pelvic fat and kidney fat in Boer goat kids

Fatty acids	Pelvic fat x ± Sx	Kidney fat x ± Sx
Lipids content, %	71.52 ± 10.38	79.42 ± 6.87
Fatty acids %		
C14:0 (Myristic acid)	1.18 ± 0.10	1.27 ± 0.13
C16:0 (Palmitic acid)	12.46 ± 0.70	13.33 ± 0.48
C16:1 (Palmitoleic acid)	1.23 ± 0.92	4.68 ± 1.93
C18:0 (stearic acid)	1.33 ± 0.08	2.07 ± 0.73
C18:1 (Oleic acid)	39.93 ± 1.95	38.42 ± 2.30
C18:2 (Linoleic acid) omega 6	1.62 ± 0.05	1.62 ± 0.03
C20:4 (Arachidonic acid) omega 6	19.26 ± 2.00	19.45 ± 1.63
C22:6 (Docosahexaenoic acid – DHA) omega 3	22.99 ± 1.72	19.16 ± 1.10
Saturated fatty acids (SFA)	14.97 ± 0.71	16.67 ± 0.83
Unsaturated fatty acids (USFA)	85.03 ± 3.91	83.33 ± 3.68
Mono-unsaturated fatty acids (MUFA)	41.16 ± 2.02	43.10 ± 2.13
Poly-unsaturated fatty acids (PUFA)	43.87 ± 3.81	40.23 ± 3.48
Desirable fatty acids (DFA)	86.36 ± 3.99	85.40 ± 3.79

nants (van Niekerk & Casey, 1988; Colomber-Rocher et al., 1992). There are some investigations on fatty acid composition of goat lean (different muscles) but there are a limited number of publications on fatty acid composition of some fat depots in goats. As some fat in depots (pelvic fat, kidney fat) are parts of the carcass and usually are included in selling primal cuts of goat carcass, it is important to investigate the fatty acid composition of these fats in Capretto kids from Boer goat in Bulgaria.

Fatty acid composition of Boer goats fat depots (pelvic fat, kidney fat) in kids weaned at 120 days of age, showed that oleic (C18:1), docosahexaenoic (DHA C22:6 Ω-3) and arachidonic (C20:4 Ω-6) fatty acids comprised the largest proportion of fatty acids, with oleic acid being the most abundant – respectively 39.93% and 38.42% (Table 3). According to some authors (Bonamone & Grundy, 1988) the high concentration of oleic fatty acid (C18:1) is directly influencing the dietetic property of meat because it reduces the level of plasma cholesterol. For this reason Banskalieva et al. (2000) suggested that the ratio of (C18:0+C18:1)/C16:0 could be useful in describing the potential health effects of different lipid types. In our study these ratios were 3.31 for pelvic fat and 3.04 for kidney fat. Similar values (from 2.25 to 3.34) published Todaro et al. (2004) and Ding et al. (2010) in different muscles of kids from several goat breeds.

According to Zigoyiannis et al. (1985, 1992) the kids fat had more hard consistency than lambs because of high amount of SFA, mainly stearic acid (C18:0). But in our investigation we received quite little values – 1.33% in pelvic fat and 2.07% in kidney fat. The biggest part from SFA has palmitic acid (C16:0) – respectively 12.46% and 13.33%. Our results were several times lower than the values for stearic acid in kid's meat received by Stankov et al. (1999) for Strandzha indigenous goats (12.28%) and those received by Vuchkov (2020) for Kalofer longhaired goat and Bulgarian screw-horned longhaired goat – respectively 14.90% and 10.78%. Received values for palmitic acid in our investigation were almost two times lower than the results from the cited authors.

In our study there were no quantified minor fatty acids with C8:0, C10:0, C12:0, C14:1, C15:0, C17:0 and C17:3 as well as some PUFA – C18:3, C20:5, C22:5 (Table 3). Our results are in accordance with several cited studies published by Banskalieva et al. (2000). These authors underlined that the main fatty acids of goat fat depots, regardless of the location of the adipose tissues in the body, are C18:1, C18:0, and C16:0 followed by C14:0, C16:1 and C18:2. That is partly in correspondence with the results in our study on fatty acids in pelvic fat and kidney fat depots.

There are several considerations regarding the nutritional value of fats and the effect of fatty acid balance on health to consumers. Desirable fatty acids (DFA) are important and include C18:0 and all unsaturated fatty acids (Banskalieva et al., 2000) because they have favourable implications on consumer health. Saturated fatty acids SFA may be harmful to health, as they tend to elevate LDL-cholesterol level (bad cholesterol). Consumers are advised to increase their overall intake of MUFA and PUFA as these fatty acids help decrease the amount of LDL-cholesterol. According to the Harvard School of Public Health (2008), SFA (the bad fats) increase the risk of cardiovascular disease and other chronic diseases, while unsaturated fats MUFA and PUFA (good fats) can improve cholesterol level in blood, stabilize heart rhythm, and have numerous other useful effects. In our study the content of DFA C20:4 Ω-6 was 19.26 and 19.45% in pelvic fat and kidney fat depots and C22:6 Ω-3 was respectively 22.99 and 19.16%.

On Table 3 are presented the results for SFA, MUFA and PUFA. The PUFA presented the highest percent of fatty acids in both fat depots – 43.87% in pelvic fat and 40.23% in kidney fat. Close to those values were the MUFA – higher in kidney fat (43.10%) than in pelvic fat (41.16%). The SFA percent were only 14.97% and 16.67% respectively. DFA were 86.36% in pelvic fat and 85.40% in kidney fat. Most of the authors showed that goat depot lipids consist mainly

of SFA (30-71%) and especially in kidney fat – from 51.55% (Sauvant et al., 1979) to 64.51% (Casey & van Niekerk, 1985). SFA followed by MUFA (20-57%) and the PUFA were less than 6% and especially in kidney fat – from 0.99% (Casey & van Niekerk, 1985) to 5.08% (Zigoyiannis et al., 1992). All shown studies were for heavy kids (chevron) after different periods of fattening. In our investigation we studied kids weaned at 120 days of age (suckling). According Muller et al. (1985) fatty acid composition of fat tissue in young kids before weaning is in relation to fatty acid composition of mother's milk fat. Increased slaughter weight increased SFA and C18:0 in all depots and the level of MUFA decreased (Sauvant et al., 1979; Werdi Pratiwi et al., 2006). That is one of the reasons for the discussed differences between our results and other cited authors with regard to SFA and PUFA percent.

The fatty acid content in goat meat and fat depots as well as some fatty acid ratios has influence over some human diseases including the Ω -6/ Ω -3 fatty acid ratio (Kris-Etherton & Innis, 2007; Simopoulos, 2006). The ratio between PUFA of the Ω -6 and Ω -3 series is an index commonly used to assess the nutritional value of fats. Within PUFA, a high proportion of Ω -3 fatty acids is beneficial while the ratio of Ω -6/ Ω -3 of less than 5 is acceptable and that close to 1 is considered as ideal (Raes et al., 2004).

The value obtained for Ω -6/ Ω -3 fatty acid ratio is close to the recommended ideal value – 0.908 for pelvic fat and 1.100 for kidney fat (Table 4). These results are lower than the published by Santos-Silva et al. (2002) for suckling lambs on pasture (1.85) and for lambs fattened on pasture with supplemented concentrates (2.59). The received values for Ω -6/ Ω -3 fatty acid ratio in our study are very favorable and indicate healthiness of capretto meat from Boer goat kids weaned at 120 days age. From nutritional point of view their participation in human nutritional schedule is desirable.

Table 4. Some fatty acid ratios and lipid indexes in pelvic fat and kidney fat in Boer goat kids

Traits	Pelvic fat	Kidney fat
PUFA/SFA	2.93	2.41
Omega 6/omega 3 fatty acids	0.908	1.100
Cholesterolemic index (h/H)	3.216	2.755
Index of thrombogenicity (IT)	0.148	0.184
Index of atherogenicity (IA)	0.202	0.221

SFA – Saturated fatty acids

PUFA – Poly-unsaturated fatty acids

PUFA/SFA is another index normally used to assess the nutritional value of fat (in meat and fat depots). The mini-

um recommendation value is 0.45 according to the British Department of Health (BHD, 1994). Other authors define an optimum value of 1.0 (FAO/WHO, 2008; WHO, 2010). That mean preferable PUFA/SFA ratio should be within the range 0.45 – 1.00. Fats presenting low PUFA/SFA are considered unfavorable, because they may induce an increase in cholesterolaemia. On the basis of proportions of the different groups of fatty acids (Table 4), the PUFA/SFA ratio varied from 2.41 in kidney fat to 2.93 in pelvic fat.

A better approach to the nutritional evaluation of fat should be the utilization of indexes based on functional effects of fatty acids, e.g. the ratio hypocholesterolaemic/hypercholesterolaemic fatty acids (h/H), computed according to present knowledge of the effects of individual fatty acids on cholesterol metabolism (Dietschy, 1998; Williams, 2000). The values obtained for this ratio were 3.216 in pelvic fat and 2.755 in kidney fat (Table 4). The obtained from us results are close to the reported from Santos-Silva (2002) for suckling lambs on pasture (2.02) and on supplemented pasture (2.04). Compared to our results for h/H index with values for carp fat, that ranges between 2.03 and 4.62 (Ivanova & Hadzhinikolova, 2015) we can summarize that cholesterolaemic index of Boer goat kids weaned at 120 days, have closer to fish fat values and can be accepted as healthy meat.

The average index of thrombogenicity (IT) is 0.148 in pelvic fat and 0.184 in kidney fat (Table 4). The values lower than 1.0 provide evidence for good anti-thrombogenic properties (Hornstra & Lussenberg, 1975). The IT values are determined by SFA that are assumed as pro-thrombogenic and PUFA that are assumed as anti-thrombogenic (Ulbricht & Southgate, 1991). The higher the IT is, the bigger the risk is for coronary disease, because IT determines the possibility for thrombogenicity (Ivanova & Hadzhinikolova, 2015).

On Table 4 are presented the results for index of atherogenicity (IA). The IA was 0.202 in pelvic fat and 0.221 in kidney fat. For lipids of animal origin, the recommended IA is from 0.5 to 1.0 (Senso et al., 2007). In our study IA values of kids lipids in both fat depots were lower than 1.0, indicating their good anti-atherogenic properties.

Banskalieva et al. (2000) summarized a lot of investigation on fatty acid composition in several muscles and in several fat depots and conclusions were that data for SFA and MUFA percentages in some fat depots are to some extent close to the average levels for SFA and MUFA in muscle lipids. Because of that we supposed that the received results in our study on fatty acid content, fatty acid ratios and the lipid indexes in two fat depots can be valid for indication of healthy goat meat.

Conclusions

Musculus *Longissimus dorsi* (LD) of Boer goat kids had the highest content of moisture (75.26%) and total lipids (3.19%) but least protein (20.59%) and minerals (0.96). The highest content of protein (22.27%) and minerals (1.30%) had Musculus *Semimembranosus* (SM). The lowest pH₂₄ was in m. *Iliapsoas* (Ips) – 5.30 and the highest – in MS 5.62. The lowest water holding capacity was found in LD – 22.06% but the highest in Ips – 27.68%. The cooking losses at roast of the three analyzed muscles ranged from 47.66% for SM to 54.75 for Ips. There were large differences between the losses at keeping – from 2.38% for LD to 5.59 for SM. The highest tenderness had Ips (368.26°P) but the least value had SM (306.74°P).

Fatty acid composition of Boer goat kids fat depots (pelvic fat and kidney fat) showed that oleic (C18:1), docosahexaenoic (C22:6 Ω -3) and arachidonic (C20:4 Ω -6) fatty acids comprised the largest proportion of fatty acids, with oleic acid being the most abundant – respectively 39.93% and 38.42%.

The poly-unsaturated fatty acid (PUFA) presented the highest percent of fatty acids in both fat depots – 43.87% in pelvic fat and 40.23% in kidney fat; mono-unsaturated fatty acids (MUFA) were higher in kidney fat (43.10%) than in pelvic fat (41.16%). The saturated fatty acid (SFA) percent were only 14.97% and 16.67% respectively. Desirable fatty acids (DFA) were 86.36% in pelvic fat and 85.40% in kidney fat.

The value obtained for Ω -6/ Ω -3 FA ratio is 0.908 for pelvic fat and 1.100 for kidney fat that is close to the recommended 1.0 as ideal value. The PUFA/SFA ratio varied from 2.41 in kidney fat to 2.93 in pelvic fat. The values obtained for cholesterolaemic index (h/H) were 3.216 in pelvic fat and 2.755 in kidney fat; the average index of thrombogenicity (IT) was respectively 0.148 and 0.184; the index of atherogenicity (IA) was 0.202 and 0.221 respectively. All the received values for FA ratios and indexes are very favorable and indicate healthiness of capretto meat from Boer goat kids weaned at 120 days of age.

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