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Physicochemical characteristics of meat from Dabene suckling lambs at weaning in 60 days of age

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Abstract

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The Dabene sheep breed is a Bulgarian local breed, adapted to mountain and semi-mountain conditions. Typically a combined breed. Traditionally, the lambs are sold for meat immediately after weaning, after which the sheep has milked for about 100-120 days. In the available specialized literature, the researches of Bulgarian authors on the meat-producing qualities of lambs until weaning are rare. The researchers mainly conducted experiments with fattened animals up to 100 -150 days of age and live weight 30 – 35 kg. The object of this study are 6 male single-born Dabene lambs, slaughtered immediately at weaning at 60 days of age, without a period of intensive fattening. The preslaughtered live weight in Dabene lambs in 60 days of age was 20.34 kg. The dressing percentage was 51.16%. The chemical composition determined of samples from m. *Longissimus thoracis* was as follows: dry matter – 27.7%, protein – 23.6%, fat – 3.29%. The fatty acids with the highest concentration in samples of m. *Longissimus thoracis* were respectively: monounsaturated oleic acid (18: 1) – 40.64%, and the saturated palmitic acid (16: 0) – 25.59%, and stearic acid (18: 0) – 15.04%. The pH values measured at m. *Longissimus thoracis* were relatively stable stored under refrigerated conditions. At 24 hours after slaughter, the pH was 5.5, and after storage for 7 days it was 5.8. Instrumentally captured color characteristics of m. *Longissimus thoracis* were as follows: the degree of lightness (L*), 24 hours after slaughter was 45.9. The relative deviation to the red color (a*) was 17.58. The relative deviation to the yellow color (b*) was 6.63. The saturation index of meat color (C), measured 24 hours after slaughter, was 17.71.

Keywords: physicochemical meat characteristics; Dabene sheep; autochthonous sheep breeds

Introduction

Consumer preferences for lamb meat are influenced by some characteristics such as price, muscle conformation, color, pH, as well as some technological properties such as texture and tenderness, juiciness, taste and smell (Teixeira et al., 2005). Studies confirm that lamb meat is rich in many vitamins, minerals and essential polyunsaturated fatty acids (Ponnampalam et al., 2016). It is because of the growing importance of meat and carcass quality for slaughterhouses and the consumers, a number of authors has studied the problem (Bennett, 1997; Bickerstaffe et al., 1996; Carlucci et al., 1999; Channon et al., 1993; Devine et al., 1993; Ellis et al., 1997; Hoffman et al., 2003; Hopkins, 1993; Hopkins et al., 1998; Purchas et al., 2002; Safari et al., 2001; Young et al., 1993). In recent years, the demand for carcasses with low fat content has increased due to increased consumer awareness of healthy eating, and especially the quality and quantity of fat in the meat. Traditional production of lambs for meat in the Mediterranean countries is based on the sale of light lambs that are slaughtered at an early age (ie 30-60 days of age), immediately after weaning, or after a short period

of fattening (Juárez et al., 2009; Santos-Silva et al., 2002). These carcasses weighing up to 13 kg are characterized by pale pink color, less fat and excellent taste (Beriain et al., 2000). In some countries with traditions in the production of lamb from local breeds, and in particular the operation of Council Regulation (EEC) № 2082/92 on the certification of specific agricultural products and geographically protected products, there is a strong incentive to produce high quality products, and sustainable storage of local sheep breeds. Producers are encouraged to produce lamb by traditional methods, and by traditional local breeds, as the products are well received by consumers (Teixeira et al., 2005). The quality of lamb meat is significantly influenced by the breed (Fisher et al., 1999; Fogarty et al., 2000; Hoffman et al., 2003; Purchas et al., 2002; Safari et al., 2001; Sanudo et al., 1997; Santos et al., 2002).

Unfortunately in Bulgaria, this practice of promoting traditional production and certification of local sheep products have reported as a serious weakness in the country's agricultural policy. The Dabene sheep breed is a local breed adapted to mountain and semi-mountain conditions. Typically a combined breed. The lambs are sold for meat immediately after weaning, after weaning the sheep are milked for about 100-120 days. In the available specialized literature, the researches of Bulgarian authors on the meat-producing qualities of lambs until weaning are rare. The researchers mainly conducted experiments with fattened animals up to 100 -150 days of age, and live weight 30 – 35 kg. However, the requirements of the modern consumer are aimed at the so-called suckling lambs, or light lambs. This requires a detailed study of the meat-producing characteristics of Dabene suckling lambs at an early age, and the possibility of obtaining meat with high taste and dietary qualities.

Materials and Methods

The object of the study were 6 Dabene lambs, originating from a herd in the native area of the breed. Transhumance is practiced in the rearing of this herd, with climbing to summer pastures up to 2000 meters above sea level (southern slopes of Stara Planina mountain, below south slopes of Jendem peak), and during the winter months, the sheep are grazing in the regio in village of Dabene, municipality Karlovo (332 meters above sea level). This is in line with the in-situ conservation of endangered genetic resources in sheep farming. The lambs selected for the study were matched by sex and type of birth – male, single. During the suckling period, lambs were raised in the traditional technology, with mother 's milk as the main food, and after the 15th day of birth, lambs had free access to alfalfa hay and concentrated feed (corn, barley and sunflower meal). The ewes from which the lambs are descended were selected according to age – 2-4 years of age. The daily ration of the sheep consisted mainly of grazing. Determinant for the experiment was reaching a certain age of the lambs – 60 days. This is in line with traditional technologies typical of the rearing of this local breed. The slaughter of the experimental animals was conducted in the experimental base of the Agricultural University – Plovdiv, after a 24-hours fasting diet, with a free access to water. The preslaughter live weight of the lambs was measured immediately before slaughter. After slaughter, the carcasses were cooled to 4°C for 24 hours. The weight of the chilled carcass and the dressing percentage were determined by the method of Zahariev & Pinkas (1979). The data were processed by the variation-statistical method.

The measurements of the physicochemical characteristics of the meat were made on a *m. Longissimus thoracis* (at the 12th rib of the left half for each carcass). Muscle pH was determined using a pH meter with a combined electrode, in case of double measurement at *m. Longissimus thoracis.* The first – after cooling (24 hours after slaughter), and the second – after 7 days, storage under refrigerated conditions at a temperature of 5℃. The meat color was measured on the same muscle at an identical time interval, using a Minolta CR200 chromometer (where L* represents relative brightness; a* shows relative deviation to red; and b* represents relative deviation to yellow). The "color saturation index", or "Chroma" (C), was calculated using values a* and b* according to Wyszecki & Stiles (1982).

The moisture content of the meat (*m. Longissimus thoracis*) was determined by air drying (AOAC, 1984, procedure 24003). The fat content was determined by the Soxhlet method – extraction in petroleum ether (AOAC, 1984, procedure 13032). The Kjeldahl method (AOAC, 1984; procedure 2057) was used to determine nitrogen, using a conversion factor of 6.25 to convert nitrogen to protein percentage. The determination of the ash was made according to AOAC 1984 (procedure 14066). To determine the fatty acid composition of the fatty extract from the meat (*m. Longissimus thoracis*) of Dabene suckling lambs, esterification of the fatty acids obtained after hydrolysis was performed by the method of Hartman & Lago (1973).

Results and Discussion

From the results presented in Table 1, it can be seen that Dabene lambs reach a relatively high live weight of 20.3 kg at weaning at 60 days of age. The weight of the cooled carcass was 10.5 kg. The slaughter yield was relatively high – 51.16%. Lower values for the slaughter yield, at significantly higher

slaughter live weight, were found by Junkuszew et al. (2020) for lambs from a synthetic meat and fertility line, 100 days old. Lower results cite Teixeira et al. (2005) in male lambs aged 90 days from the Bragancana and Mirandesa breeds in Portugal. The results obtained for the Dabene lambs were lower than those found by Vuchkov (2020) at 60 days old suckling lambs from White and Patched face Maritsa sheeps.

The results for the quality characteristics of lamb meat are presented in Tables 1 and 2. The pH of chilled meat is important as it affects the color, quality and shelf life. At 24 hours post mortem pH values of chilled meat from Dabene suckling lambs averaged 5.55. The pH parameters obtained by us were in the range of the desired values from 5.5 to 5.8 at which the meat is considered to be light colored and tender (Gardener et al., 1999). According to Devine et al. (1993), exceeding the maximum limit of 5.8 is considered as undesirable.

Table 1. Some slaughter parameters and chemical composition of *m. Longissimus thoracis* (24h post mortem), in Dabene lambs, slaughtered at weaning at 60 days of age (n-6)

Features	X±SD
Preslaughtered live weight, kg	20.347±2.285
Weight of carcass, kg	10.508±1.521
Slaughtered yield, %	51.165±1.990
Dry matter, %	27.710±0.342
Protein, %	23.641±0.750
Fat,%	3.290±0.673
Ashes, %	0.979±0.002
W/P index	3.060±0.781

Table 2. pH, color characteristics (L*, a*, b*, C), percentage distribution of myoglobin forms, and hydrolytic, oxidative changes in lipid fractions in *m. Longissimus thoracis*, from Dabene lambs at 7 days refrigerated storage (0 + 4°C)

Features	m. *Longissimus thoracis*	
	24h post mortem	7 days post mortem
pH	5.55^{a}±0.05	5.80^{b}±0.05
L*	45.90^{b}±1.03	43.88^{b}±1.82
a*	17.58^{a}±0.75	19.34^{b}±0.86
b*	6.63^{b}±0.88	2.86^{a}±0.62
C	17,713±0,314	19,550±0,426
DeoMb	1.43^{a}±0.01	1.41^{a}±0.05
OxyMb	0.71^{b}±0.05	0.46^{a}±0.08
MetMb	0.19^{a}±0.04	0.46^{b}±0.04
POV, µeqO2/kg	1.39^{b}±0.08	0.50^{a}±0.05
AV,mgKOH/g	0.42^{a}±0.03	1.00^{b}±0.16
TBA,MDA/mg/kg	1.34^{a}±0.07	3.19^{b}±0.84

According to Warris et al. (1984) and Warner et al. (1998), this pH range (5.99 – 6.5) is usually associated with darker and firmer meat, with increased water holding capacity, which contributes to greater possibility of bacterial damage of the meat, and correspondingly shorter shelf life. Our results are similar to those obtained by Safari et al. (2001), Hoffman et al. (2003). Live weight at slaughter undoubtedly affects the pH of the meat. Sanudo et al. (1996) and Beriain et al. (2000), studying Spanish lambs, also observed higher pH in heavier carcasses, but Vergara et al. (1999) found no effect of carcass weight on pH. Although the Dabene lambs in our study, had a higher live weight at slaughter, the results were similar to those found by Teixeira et al. (2005) for meat from significantly lighter lambs from Bragancana and Mirandesa sheep breeds. Our results showed that the pH of the meat of Dabene lambs at 60 days of age has comparative stability when stored in refrigerated conditions. The pH values on day 7 of storage of meat at a temperature of 6 ℃ was average – 5.80. The results of the chemical analysis of m. *Longissimus thoracis* of Dabene suckling lambs are presented in Table 1. The percentage of moisture was relatively high – 72.29%. Higher water content is characteristic of meat obtained from animals slaughtered at an early age and fed mainly with milk. During the suckling period, the main nutrients for the suckling lambs come from breast milk, and after weaning from plant foods (Scerra et al., 2007). In our previous studies of meat from 60 days old lambs from Withe and Patched face Maritsa sheeps we founded a lower moisture content (Vuchkov, 2020). The moisture content in the meat of fattened 120 days old Karakachan and Sakar lambs was significantly lower (Raichev et al., 1984).

In the current study, the relatively high percentage of protein was also impressive – 23.64%. For comparison, in 100 days old lambs from a synthetic meat line, the protein was 20.73 (Junkuszew et al., 2020). Undoubtedly, diet and rearing technology affect to the chemical composition of the meat. Low-energy daily rations, such as all-vegetable rations, increase the daily rate of protein accumulation and slow down the accumulation of fat, which in turn increases the water content in the muscles. Thus, when plant-based fodder (grass and hay) is included in the ration instead of concentrate mixtures, it is expected to increase the moisture and protein in the meat and reduce its fat content (French et al., 2001; Velasco et al., 2004; Lee et al., 2008). Under similar rearing and feeding conditions to the our study, Panea et al. (2011) found a lower protein content in the meat of lambs from the Churra Tensina breed in northern Spain. The fat content in m. *Longissimus* of 60-day-old Daben lambs was 3.29%. Panea et al. (2011) reported lower fat content in lambs of the Churra Tensina breed in northern Spain. The

W/P index is directly related to the maturity of the meat. The values established by Kesava Rao et al. (2003) vary in the range of 3.10-3.87 according to the protein content of the ration. The higher protein content of the food, the higher the value of the W/P index. The index established by us for meat of 60 days old Dabene lambs was 3.06.

The degree of lightness (L*) for meat of 60 days old Dabene lambs, 24 hours after slaughter was 45.90 (Table 2). Babiker et al. (1990) cite that goat meat has lower values for L* (darker meat) and b* (less pronounced yellowish tinge), and higher values for a* (more pronounced reddish tinge), compared to lamb meat. This is confirmed by our previous study on meat from Bulgarian Screw-horned kids slaughtered at 90 days of age, in which L* was lower – 42.47 (Vuchkov et al., 2021), compared to those found in Dabene lambs, despite that the brightness (L*) decreases with increasing live weight. Such an effect of live weight on the instrumental color characteristics of meat was found by Sanudo et al. (1996); Vergara et al. (1999); Beriain et al. (2000); Santos Silva et al. (2002), and Fogarty et al. (2000). Despite the higher live weight at slaughter of the Dabene lambs (20.3 kg), studied in the present work, has lighter meat than lighter suckling lambs from Bragancana and Mirandesa breeds (16.1 kg) (Teixeira et al., 2005).

The differences can be explained by the younger age at the slaughter in the Dabene lambs – 60 days. Pieniak-Lendzion et al. (2009) point out that with increasing age, the lightness decreases and the meat becomes darker. In the meat of 60 days old Dabene lambs, the deviation to the red color a* was 17.58. Lower values for this indicator cite Teixeira et al. (2005). In accordance with our results, Santos Silva et al. (2002) examining Portuguese merino lambs found that live weight had an effect on a*. According to Sanudo et al. (1997) light lambs traditionally preferred in the Mediterranean have a lower index of deviation to the yellow color due to milk consumption in suckling period and low iron content in the diet. In the our study, the index of deviation to the yellow color b* in 60 days old Dabene lambs was 2.17. Significantly higher values indicate Teixeira et al. (2005). Some authors point to a significant effect of the breed on this indicator (Fogarty et al., 2000; Sanudo et al., 1997), but in Dabene lambs the lower age at slaughter – 60 days – is responsible for the lower values of b*. The meat color saturation index (C) in Dabene suckling lambs, measured 24 hours after slaughter, was 17.71.

From the results in Table 2, it can be seen that the instrumentally recorded color characteristics of the meat of 60 days old Dabene lambs are relatively stable when stored under refrigerated conditions. After 7 days of storage at 5℃, the red index (a*) increased slightly to 19.34. We also report a minimal increase in the color saturation index (C) -19.55.

One of the most important factors influencing consumers' decisions to buy meat is the cherry red color (Mancini & Hunt, 2005). Very often meat cannot be sold at the maximum price due to a change in its color. The brown tinge of the meat is caused by the oxidation of muscle chemo-pigment, from red oxymyoglobin to brown metmyoglobin (Jose et al., 2008). The increase in metmyoglobin during seven days of refrigerated storage (0 + 4°C) at the total pigment content is an indicator of the change in meat color (Pogorzelska et al., 2018). In the present article, metmyoglobin measured on day 7 was twice as high as on the first day post mortem (Table 2), and at the same time oxymyoglobin decreased one and a half times ($p<0.05$). These results are a consequence of the oxidation process of oxymyoglobin during meat storage (0 + 4°C). The results for the metmyoglobin formation observed in samples from m. *Longissimus thoracis* from Dabene lambs stored for 7 days at t 0 + 4°C were lower than those reported by Adeyemi et al. (2016), which found five times higher metmyoglobin values during 7 days refrigerated storage of goat meat. Attractive fresh meat color is the most important quality parameter for consumers (Adeyemi et al., 2016). The reddish hue and lighter color are associated with meat oxidation (Sabow et al., 2016). In the case of Dabene lambs, the meat stored under refrigerated conditions for 7 days, no significant differences in color were observed in terms of red enhancement or lightening.

Today, consumer taste is demanding not only on the quantity of fat in the meat, but also on their quality. The fatty acid composition in lamb meat can be influenced by certain factors such as breed, sex, live weight, rearing conditions, degree of fattening (Nuernberg et al., 2008; Juárez et al., 2009; Wood & Enser, 1997). Since the breed is one of the main factors influencing the fatty acid composition of the meat, the results obtained in 60 days old Dabene light lambs can be considered representative of the nutritional and dietary value of the meat from this local breed. From the values presented in Table 3, with the highest concentration in samples of m. *Longisimuss thoracis* were monounsaturated oleic (18: 1), and saturated palmitic (16: 0) and stearic (18: 0). This is in line with the findings of some authors (Kemp et al., 1981; Rowe et al., 1999; Kosulwat et al., 2003; Velasco et al., 2004; Arana et al., 2006).

It is believed that monounsaturated oleic fatty acid is related to lowering blood cholesterol in human, and for that, it has the highest relative content (40.64%) in the meat from Dabene suckling lambs emphasizes its dietary qualities. Similar values have been reported by Panea et al. (2011) in lambs of the Churra Tensina breed, in northern Spain.

Table 3. Intramuscular fatty acids (%) in *m. Longissimus thoracis*, 24 h post mortem, in Dabene lambs slaughtered at 60 days of age (n-6)

Fatty acids	X±SD
Caprylic fatty acid C 8:0	0.25±0.09
Capric fatty acid C 10:0	0.33±0.15
Lauric fatty acid C 12:0	4.40±1.41
Myristic fatty acid C 14:0	1.02±0.39
Palmitic fatty acid C 16:0	25.59±2.46
Palmitoleic fatty acid C 16:1	2.76±0.34
Margarine fatty acid C 17:0	1.65±0.50
Margarinoleic fatty acid C 17:1	1.15±0.29
Stearic fatty acid C 18:0	15.04±1.98
Oleic fatty acid C 18:1	40.64±2.75
Linoleic fatty acid C 18:2	3.22±0.75
Linolenic fatty acid C 18:3	1.92±0.53
Saturated fatty acids, %	49.10±2.63
Polyunsaturated fatty acids, %	39.48±2.52
Monounsaturated fatty acids, %	7.86±1.10
Polyunsaturated / Saturated fatty acids	0.80±0.16
Desirable fatty acids, % (C 18:0 + total unsaturated)	63.43±0.10

The degree of fat saturation is one of the most important characteristics affecting the quality of meat. Long-chain saturated fatty acids harden easily when cooled and affect the taste of meat. The total amount of saturated fatty acids in the meat from Dabene lambs was 49.10%. Some authors have found that the fatty acid composition of milk in grazing sheep, reflects on the meat of suckling lambs (Velasco et al., 2004; Scerra et al., 2007). Unweaned lambs raised on pasture shows higher concentrations of saturated long-chain fatty acids such as C18: 0 and C20: 0 (Kemp et al., 1981; Velasco et al., 2001; Aurousseau et al., 2007; Nuernberg et al., 2008; Panea et al., 2011).

The relatively high content of stearic fatty acid (18:0) in the meat of Dabene lambs (15.04%) is decisive for its good dietary qualities. The values obtained by us are higher than those established by Panea et al. (2011) in lambs from the Churra Tensina breed, in northern Spain This fatty acid belongs to the group of "desirable" fatty acids related to human dietetics. "Desirable fatty acids" are stearic (C18:0) and all unsaturated fatty acids (Banskalieva et al., 2000). The total percentage of "desired fatty acids" in the meat from Dabene lambs slaughtered at 60 days of age was 63.43%.

An important point in the analysis of the results was the consideration of the average values of caprylic (C8) and capric (C10) fatty acids. In the meat from Dabene lambs has a relative content as follows – 0.25% (C8) and 0.33% (C10). According to some authors (Voyvodova & Mihailova, 2001), these fatty acids are crucial for the taste and smell of both milk and meat, in small ruminants. It is the relatively low content of caprylic and capric fatty acids in the meat of 60 days old Dabene lambs that can be attributed to the fact that there was no strong species-specific odor. This is defined as a positive certificate for the taste of meat for this local breed. In order to more fully characterize the dietary properties of the meat of Dabene suckling lambs, it is necessary to note the content of essential linoleic Ω6 (C18: 2) and linolenic Ω3 (C18: 3) fatty acids, as well as the ratio between them.

A number of authors have determined the dietary qualities of ruminant meat on the basis of conjugated linoleic acid, emphasizing its anticancer and antiatherosclerotic effects (Belury, 2003; Kritchevski, 2003; Khanal & Olson, 2004). In the our study, linoleic acid has a relatively high content of 3.22% and linolenic acid -1.92%. The ratio of polyunsaturated to saturated fatty acids is also crucial for the dietary qualities of meat. Some authors define as desirable values of this ratio close to one and lower than 5 (Enser et al., 1998; Raes et al., 2004). We report a ratio of polyunsaturated to saturated fatty acids in the meat of 60 days old Dabene lambs close to one – 0.80, which was considered to be extremely favorable for its dietary characteristics.

Conclusions

The chemical composition established in *m. Longissimus thoracis*, in Dabene suckling lambs, slaughtered at 60 days of age was as follows: dry matter – 27.710; protein – 23.641; fat – 3.2. 2. The pH value measured at *m. Longissimus thoracis* has showed relatively stable values when stored under refrigerated conditions. At 24 hours after slaughter the pH was 5.5, and after storage for 7 days it was 5.8. Instrumentally captured color characteristics of *m. Longissimus thoracis* from Dabene lambs, slaughtered at weaning at 60 days of age were as follows: lightness (L*), 24 hours after slaughter was 45.90; the relative deviation to the red color (a*) was 17.58; the relative deviation to the yellow color (b*) was 6.63; the meat color saturation index (C) was 17,713. Fatty acids with the highest concentration in samples of *m. Longisimuss* were monounsaturated oleic (18: 1) – 40.64%, and saturated palmitic (16:0) -25.59%, and stearic (18: 0) -15.04%. The metmyoglobin fraction measured after 7 days of storage of meat under refrigerated conditions was twice as high as measured on the first day post mortem (0.19 – 0.46), and at the same time the oxymyoglobin fraction decreased 1.5 times ($p < 0.05$) .

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