Tulum cheese – cheese making technology and main characteristics

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SUMMARY
Tulum cheese is a specific kind of cheese which is typical of the countries of the Balkan Peninsula, but some of its varieties are also produced in Algeria and Lebanon. In the different countries the cheese is designated with different names. In Romania it is known as brânzâ de burduf, in Bosnia and Herzegovina its name is mjeh, in Croatia it is called mišina or sir iz mišine. In Algeria it is known as bouhezza and in Lebanon as darfiyeh. In Turkey and Bulgaria it is designated as tulum cheese. In fact, the variety of names for this kind of cheese in the different languages is related to the specific step of technology which is applied in the production of the cheese.

The unique traditional technology is characterized by ripening of the cheese curd in an animal skin bag (tulum), which
has been prepared for this purpose in advance. Traditionally, the cheese is made from raw sheep’s or goat’s milk, but it is also possible to use cow’s milk or a mixture of these kinds of milk. There is also some variety in the technological processes in the cheese production.

The lactic acid bacteria are the main microflora of the cheese, but in some cheese varieties yeast and moulds are also found. The specific and strong taste and flavour of the cheese is due to the proteolytic and lypolytic activity of its specific microflora which takes part in the processing of the cheese curd and during the cheese ripening.

**Key words:** tulum cheese, cheese making technology, main characteristics

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**INTRODUCTION**

The global market expansion has threatened existence of local practices, traditions and knowledge, which are historically associated with certain geographic, socio-cultural and ethnic groups of people. The homemade food prepared only from raw materials obtained from local animal breeds which are feed with traditionally used plant species in a particular geographical region or area, is connected with preservation of biodiversity (Scintu and Piredda, 2007).

Recently, the interest towards specific kind of cheeses prepared in a traditional homemade manner or in small dairy plants according to the traditional technology has grown (Paxson, 2010; González-Córdova et al., 2015; Blazic et al., 2017). Tulum cheese belongs to this specific group of artisan cheeses.

Detailed scientific review articles have been published (Hayaloglu et al., 2007), Kamber and Terzi, 2008) and Kalit et al., 2010) which dealt with the main
al., 2010), which look at the main technological, microbiological and sensory characteristics of the cheese, but as a matter of fact, the cheese has gained a lot of interest during the last years. The constantly published new researches have revealed the attempts for preserving the typical characteristics of the product (Cakmakci et al., 2011; Tarakci and Durmu, 2016), showed the different components involved in the cheese flavor and taste (Serhana et al., 2015; Medjoudj et al., 2017), and have detected the presence of some pathogens and toxins.

The experiments on the natural microflora of the cheese made by artisanal technology are coupled with the attempts to compose and apply a proper starter culture for cheese production (Kunduhoglu et al., 2012; Frece et al., 2016).

The aim of the current review is to present a part of the new data concerning the main technological steps of the tulum cheese making technology; the participating species and their scale quantity proportion in the cheese microflora and discuss briefly the presence of some undesirable microorganisms and toxins in the cheese.

Tulum cheese varieties and main physicochemical characteristics

Tulum cheese varieties can be found under different names not only in different countries but also in different geographical regions of one country. According to Cakmakci et al., (2008) and Tuncer (2009), through more than 50 varieties of cheeses produced in Turkey *tulum cheese, beyaz* and *kasar cheese* are the most popular. Hayaloglu et al., (2007) have cited the data of the Turkish statistical institute (Ankara, Turkey) about the annual tulum cheese production which was estimated at 10 000 tons per year in 2004 and the researchers marked that the amount of production volume and the numbers of dairy plants which
produced tulum cheese continued to grow.

According to Kirdar et al., (2015) some of the designation of the tulum cheese varieties are as follows: savak tulum (Erzincan), divle tulum (Karaman), cimi tulum (Antalya), kargi tulum cheese (Corum) and brined tulum cheese (Izmir). Additional information about tulum cheese is presented in the article of Kamber and Terzi (2008), and more of the characteristic details of the cheese varieties can be found in the publication of Hayaloglu and Karagul-Yuceer (2011). The akcakatik cheese can be referred also as a kind of tulum cheese, because it ripened in a goat’s stomach (Kirdar et al., 2017).

The review article of Kalit et al., (2010) presented the main varieties of tulum cheese which are produced in Croatia, Bosnia and Herzegovina and Monte Negro.

The research of Zitoin et al., (2012; 2017) studied in details the bouhezza cheese, which is a cheese typical for the East regions of Algeria and which also ripens in prepared goat’s skin bag. According to the opinion of Zitoin et al., (2011) the bouhezza cheese turns out to be the only one of their national cheeses which undergoes a period of ripening. In the North mountain region of Lebanon the tulum cheese is designated as darfiyeh. Describing the darfiyeh cheese Serhan et al., (2009) point up the handmade manner in cheese technology, the usage of raw goat’s milk without addition of starter culture and ripening in the animal skin bag.

Depending on the content of water in the solids non-fat the cheese varieties which ripened in the animal skin bag can be classified as hard or semi-hard and according to the contents of fat in solids as full fat or low-fat cheeses (Kalit et al., 2010). In Table 1 are shown the main physicochemical characteristics of tulum
Some exceptions are the bouhezza cheese made from cow’s milk which has a low value of total solids – 35.98% (Zitoin et al., 2012), and also three samples of tulum cheese which dry solids matter reaches 71 and 75% according to the data of Kunduhoglu et al., (2012) or even higher in the tulum cheese variety akcakatic cheese - 79.71% (Kirdar et al., 2017). Depending on fat, the lowest estimated value is 20.53% (Dinkci et al., 2012), and the highest – 39.5% is in the research of Kunduhoglu et al., (2012). The shifts from the average value are several cheese samples. The cited from Zitoin et al., (2012) bouhezza cheese had a fat content of 14.50%, and this particular fat content was even lower than the fat of the examined by Celik and Tarakci (2017) the low-fat tulum cheese with a fat content 16.25%. On the contrary, in the examined by Kunduhoglu et al., (2012) tulum cheese sample fat content reaches 44.3%. Protein contents of the tulum cheese vary in a comparatively narrow range and the experimentally estimated minimal value was 16.8% (Zitoin et al., 2012) and the maximum value was 26% (Kunduhoglu et al., 2012). With regard of the salt content the minimum content is 2.46% (Celik and Tarakci, 2017), and the maximum - 6.31% (Akpinar et al., 2017). According to the measured active acidity of the cheese the lowest estimated value is pH=3.69 (Kirdar et al., 2017), and the highest pH is 5.48 (Hayaloglu et al., 2007).
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<th>№</th>
<th>Cheese varieties</th>
<th>ухо в вещество %</th>
<th>лактук</th>
<th>в сухото вещество %</th>
<th>&gt;Total Solids</th>
<th>Salt, %</th>
<th>Fat in solids dry matter, %</th>
<th>Protein, %</th>
<th>лактина киселина Acidity, %</th>
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<tr>
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<td>3.276</td>
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<td>Gor et al., 1991</td>
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<td>62.83</td>
<td>60.49 ±</td>
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<td>19.78</td>
<td>0.72</td>
<td>5.48 ±0.03</td>
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<td>5.48 ±0.03</td>
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<td>3.51</td>
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<td>1.75</td>
<td>2.92</td>
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<td>4.82</td>
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<td>56.27</td>
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<td>25.90</td>
<td>1.074</td>
<td>5.42 ±0.61</td>
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<td>3.69</td>
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<td>55.6</td>
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<td>26.0</td>
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<td>59.1</td>
<td>3.6</td>
<td>25.1</td>
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<td>5.20</td>
<td>Kunduhoglu et al., 2012</td>
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<td>14</td>
<td>Тулумско сирене (овче мляко)</td>
<td>59.20</td>
<td>31.06</td>
<td>52.47</td>
<td>3.95</td>
<td>6.67</td>
<td>1.005</td>
<td>5.153</td>
<td>Arslaner and Bakirci, 2016</td>
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### Cheese making technology

The cheese technology is a sophisticated multileveled process, which aims at transforming milk and curd into a specific final product, with its own structure-texture and sensory characteristics (Kindtedt, 2014).

Production of semi-hard and hard cheese varieties includes production steps as milk coagulation, partial drainage of the curd and molding as well as an appropriate ripening period.

The variety of more than 1,000 artisan cheeses is due to variety of the heating temperature or the regime of milk pasteurization, the different types and combinations of milk rennet coagulation, cutting, self-pressing or pressing with additional weights (Blazic et al., 2017).

Raw milk is a primary source for artisan...
al., 2017). To surovin za tr diционното тulumsko sirenе се използув сурово мляко, предимно овече и козе з ра вид и оттеждите малко- до иви животни в селските ра йони и особено в ра йони с небл гоприятни геогр фски и клим тични условия (Boyazoglu and Morand-Fehr, 2001; Alichanidis and Polychroniadou, 2008).

Пецифичнити съст ви и х р ктерни сквойствата и козето мляко, които с обект на редица изследвания (Jandal 1996, Park et al., 2007; Raynal-Ljutovac et al., 2008) без съмнение оказват влияние върху качеството на получаваното сирене и са решаващи за специфичния му вкус и аромат (Albenzio and Santillo, 2011).


Редицата отни и в ритъма при които се отваря овече и п створица при 65°C з 30 мин (Gurses и Erdogan, 2006). Изследванията на Celik и Tarakci (2017), при производството на нискоцелен тulumско сирене от кр ве мляко температурата на подсирване е дори още по-висока - 85°С, з 10 мин. Подсирянето на малкото изследовани телите посочва т р знообр з- н по произход и сил сирищна ма.

The specific content of components and distinctive properties of sheep’s and goat’s milk are objects of many scientific researches (Jandal 1996, Park et al., 2007; Raynal-Ljutovac et al., 2008) and undoubtedly have an influence on the quality of produced cheese and also are decisively important for its taste and flavor (Albenzio and Santillo, 2011).

In the early stages of tulum cheese production Kirdar et al., (2015) stated that the raw milk (15-20kg), used for production of Kargi tulum was filtered in order to remove the solid contamination of milk, and Oksuztepe et al., (2005) noted that the source milk must be free from any foreign chemicals or inhibitory substances.

The raw milk is heated to the proper temperature for addition of rennet which vary in a narrow range - 31° (Yilmaz et al., 2005, Colak et al., 2007) or a higher with several degrees - 35° (Cakir and Cakmakci, 2018). The milk heating temperature for cow’s milk used by Gurses and Erdogan (2006) was even lower - 30°.

Among the research data can be found some variants which use the cow’s milk and pasteurization of 65°C for a 30 min (Gurses and Erdogan, 2006), and in the study of Celik and Tarakci (2017), during the production process of a low-fat tulum cheese the pasteurization temperature is even higher - 85° for 10 min.

The researchers use rennet of different kinds and strength. In the technology process sited by Cakir and Cakmakci,
According to the artisan technology starter culture and calcium chloride are not used, but they are included in the experiment of Celik and Tarakci (2017), and Yilmaz et al., (2005) additionally applied a microbial lipase. Most of the scientists share the common opinion that obtaining the firm curd takes from 60 to 90 min except Yilmaz et al., (2005), who started curd cutting on 30th minutes after addition of rennet.

The curd is cut or manually broke up to pieces with a size of 1x1x1cm (Yilmaz et al., 2005, Cakir and Cakmakci, 2018), 2x2x2cm (Gurses and Erdogan, 2006), 3-4cm³ (Celik and Tarakci, 2017) or 5x5cm (Oksuztepe et al., 2005). Additional heating (up to 50° for 12-15 min) of the cheese curd pieces, in order to expel more whey from curd is mentioned only in the technological scheme sited from Colak et al., (2007).

As a rule, in all reviewed in this paper technologies, the drainage of cheese curd is done by pressing with different weights and with different time duration – as a example 60 kg for 12 hours (Gurses and Erdogan, 2006), a press operation with duration 3.5-4 hours (Karagozlu et al., 2009), 2-kg weights on every 10 kg curd for 2 hours (Celik and Tarakci, 2017). In some cases the press operation is performed by the weight of filled with curd cotton bags at the temperature of 20°C for a period of 24 h (Cakir and
Filled in a skin bag and the cheese curd was seen also in the technology of Oksuztepe et al. (2018). After the initial press operation the curd is further cut to pieces with size of pea and salted to 2% (Oksuztepe et al., 2005), to 2.5% (Celik and Tarakci, 2017), to 3% (Cakir and Cakmakci, 2018), to 3.5% (Gurses and Erdogan, 2006). Additional press operation was applied in the work of Gurses and Erdogan, (2006) – as a weight of 30kg for a period of 3-4 hours, the drainage of salted curd can be found in the technology of Celik Tarakci (2017), for a period of 24 hours at room temperature and applying the weights on the cheese curd is seen also in the technology of Oksuztepe et al., (2005). Yilmaz et al., (2005) mentioned also the period of prefermentation during the curd processing and a decrease in the active acidity to the particular value - pH 5.10, as a result of ongoing lactic acid fermentation. In some particular technologies the salted curd ripens in glass packaging at the temperature of 10±2°C for 3 months (Gurses and Erdogan, 2006) or at 4±1°C for 120 days (Celik and Tarakci, 2017), it can ripen also at 4±1°C for 90 days in plastic containers according to Cakir and Cakmakci (2018). Filled in a skin bag curd can ripen at 2-4°C (Karagozlu et al., 2009), at 6±1°C (Kirdar et al., 2015) or even higher 7-8°C for 90 days (Colak et al., 2007, Yilmaz et al., 2005), but also at temperature of 10-12°C (Serhan et al., 2009). According to Serhan et al., (2009) during the production process of the darliyeh cheese the skin bag was filled with a hand shaped cheese pieces with an average size of 12x9x9cm, and the expelled whey was collected, subjected to heating and by addition of some quantity of raw ewe’s milk the whey proteins have been coagulated. Obtained proteins have been coagulated
According to Erdogan and Gurses (2005) the tulum cheese technology includes the usage of raw skim milk, rennet and by heating the curd is obtained so called civil cheese and the previously prepared packages (which can be animal skin bags or plastic bags) are filled with the mixture of the processed curd and the whey cheese (lor).

Tightly sewed animal skin prevents air entering inside the bag and in a homemade technology skin bag can be stored in rooms with natural cooling. Guven and Onar (1994) have studied the samples in which the hairy surface of prepared skin was directed inwards or outwards of the inside space of animal skin and the cheese curd. Because of a higher number of coliform bacteria yeast and mould in the samples with the hairy surface inside, in comparison to the others samples, authors have drawn the conclusion that the goat`s skin bag with the hairy surface inside is not suitable for tulum cheese packaging. The technology sited by Zitoin et al., (2011) for bouhezza cheese the hairy surface of the skin was inwards. According to the technology of Cakir and Cakmakci (2018) before the filling the packages the curd was mixed with a black cumin.

Comparatively different is opinion of Litopoulou-Tzanetaki and Tzanetakis (2011), who concluded that the technology of a touloumissio cheese (touloumotyri), which is a Greek designation of tulum cheese (touloumia), is pretty much the same as the technology of Feta cheese, despite existence of some modification in the technology process. The researchers mentioned that the cheese is produced from raw sheep’s or goat’s milk or from

by this manner, whey cheese was mixed with the cheese curd and was introduced inside the ewe’s skin bag through the neck.
The mixture of these milks, but consider that after salting and ripening the matured cheese is cut into small pieces and filled in the prepared animal skin bag. The researchers noted the high salt content of cheese and also the use of brine which in turn can reach the salt content of 5.56–7.35%.

Very interesting is the manner of bouhezza cheese production explained in the publication Zitoin et al., (2011) and also in the work of Medjoudj et al., (2017). The original technology of cheese is based on the use of raw goat’s, ewe’s, cow’s milk or from a mixture of these. The technological steps involved a spontaneous fermentation, drainage and ripening of the cheese inside the prepared skin bag (which has an inside volume of about 10 to 15L). The cheese is produced by using so called lben, which is fermented milk obtained by a spontaneous fermentation of raw milk at the temperature of 20-25°C for a period of 24 to 48h without addition of starter culture. The fermented milk is partially skimmed before use in the bouhezza cheese technology. The prepared animal skin chekoua, firstly is filled with 2-3L lben, which helps for the proper treatment of skin and removes undesirable smell.

The technology process starts with filling the animal skin with a small portion of fermented lben and salt in quantity of 0.25g/L, this provides the initial biochemical changes of milk for 3-4 days. The successive addition of portions salted lben is repeated every 4 days until the skin bag is completely filled, the whole process continues almost 7 weeks. The changes of cheese curd have happened simultaneously with its ripening and at the end of the ripening period (around 10th week), in the same manner, raw full fat milk is added into the cheese mixture (the quantity of a raw milk is 2 to 3L for each chekoua).
мълчката масленост на сиренето, доб венлото количество коригир съдърж найто на сол и киселинността на готовия продукт, бр брот т н сиренето може да з върши с доб вянето на лют в червен пипер.

микрофлора на сиренето
овиш в нето на киселинността и първото чин т ч стичн протеолиза на млакото с ключови процеси в н ч лите ет пи от производството на сирене. киселинообр зув нето е в жно з улесняв не н ко гул цият и з потиск не р звиятнето н п тогени (Fox, 1989; McSweeney, 2004; Fernandes ed., 2009). ри производството н тр диционни сирен, без доб вяне н ст р- терп култур, основният ф ктор з киселинообр зув нето, след тов и з протичащите процеси на протеолиза и липолиза т е естествено присъстващ цт т сувовото млако микрофлора и микроорганизмите, които попадат в суровото млако и микрофлора на сиренето с това в нето на сиренето при производството сиренето и липолиза на продукта забавя (Montel et al., 2014; Gobbetii et al., 2015).

повишаване на киселинността и първичната частична протеолиза на млакото са ключови процеси в началните етапи от технологията на сирене. киселинен образуване е важно за улесняване на коагулацията и за потискане на развитието на патогени (Fox, 1989; McSweeney, 2004; Fernandes ed., 2009). в технологията на производството на традиционни сиренени продукти, без добавяне на стартерна култура, основният фактор за киселинен образуване, а след това и за протичащите процеси на протеолиза и липолиза е естествено присъстващата в суровото млако микрофлора и микроорганизмите, които попадат в суровото млако и ликурам при производството на сиренето (Montel et al., 2014; Gobbetii et al., 2015). това затова е важна за улесняване на коагулацията и за потискане на развитието на патогени (Fox, 1989; McSweeney, 2004; Fernandes ed., 2009). в технологията на производството на традиционни сиренени продукти, без добавяне на стартерна култура, основният фактор за киселинен образуване, а след това и за протичащите процеси на протеолиза и липолиза е естествено присъстващата в суровото млако микрофлора и микроорганизмите, които попадат в суровото млако и ликурам при производството на сиренето (Montel et al., 2014; Gobbetii et al., 2015). това затова е важна за улесняване на коагулацията и за потискане на развитието на патогени (Fox, 1989; McSweeney, 2004; Fernandes ed., 2009). в технологията на производството на традиционни сиренени продукти, без добавяне на стартерна култура, основният фактор за киселинен образуване, а след това и за протичащите процеси на протеолиза и липолиза е естествено присъстващата в суровото млако микрофлора и микроорганизмите, които попадат в суровото млако и ликурам при производството на сиренето (Montel et al., 2014; Gobbetii et al., 2015). това затова е важно за улесняване на коагулацията и за потискане на развитието на патогени (Fox, 1989; McSweeney, 2004; Fernandes ed., 2009). в технологията на производството на традиционни сиренени продукти, без добавяне на стартерна култура, основният фактор за киселинен образуване, а след това и за протичащите процеси на протеолиза и липолиза е естествено присъстващата в суровото млако микрофлора и микроорганизмите, които попадат в суровото млако и ликурам при производството на сиренето (Montel et al., 2014; Gobbetii et al., 2015). това затова е важно за улесняване на коагулации...
molecular methods, along with the presence of Lactobacillus plantarum. Serhan et al., (2009) detected also Lactobacillus curvatus. Additionally to Streptococcus thermophilus and some others species of group D of the genus Streptococcus, the researchers detected also more diversity among the isolated enterococci and besides Enterococcus faecium they isolated also E. durans, E. faecalis и E. malodoratus. They found also lactococci of the species Lactococcus lactis subsp. lactis и L. lactis subsp. cremoris.

The number of round shaped bacteria (S. faecalis) in the early stages of cheese ripening was noticed by Bostan et al., (1992), and also the presence of strains Lactobacillus casei и Lactabacillus plantarum. In the dairy plant produced the tulum cheese, along with the aforementioned species, the authors isolated also S. faecium and S. lactis. Comparatively low was the quantity of bacteria of the genera Leuconostoc и Pediococcus. According to the researchers, the species of a great importance are yeast of genus Geotrichum candidum, and also as detected by Erdogan et al., (2003) blue moulds Penicillium requeforti.

A team of researchers studied the microflora of two kinds of tulum cheese from cow’s milk. One sample was inoculated with Penicillium requeforti and ripened in the plastic package for 4 months (Erdogan and Gurses, 2005). The other sample didn’t contain moulds and ripened in a glass vessels for 3 months (Gurses and Erdogan, 2006). The researchers isolated 228 strains of lactic acid bacteria from the mould cheese and for its identification used API strip, and isolated 253 strains lactic acid bacteria from cheese without moulds. The final results showed that at the end of the cheese ripening in cheese with moulds the most abundant strains (53.3%) belongs to the genus Enterococcus ssp.,
принлежат към род Enterococcus sp., 26.7% се отнасят към род Lactobacillus ssp. В двата типа сирене изследователите установиха Enterobacter faecalis, който е в по-голямо количество в сиренето с плесен (40.0%), в сиренето без плесен достига 13.6% и нм ляв до 3% през периода на зреене. Нями е тенденция за L. lactis, който в свежото сирене без плесен предст вявля 4.5% от микрофлората и количество нм ляв през периода на зърнене. Аналогична е тенденция на L. paracasei, който в свежото сирене без плесен достига 4.5% от микрофлората, а в сиренето с плесен достига 14.7% и достига до 9.1% през периода на зърнение. Противоположно е изменението на Leuconostoc mesenteroides, който е в по-голямо количество в сиренето с плесен (9.1%), а в сиренето без плесен достига 6.7%. В сиренето с плесен Pediococcus acetilactici достига 6.7%, а в сиренето без плесен достига 18.2%, като общо и зародени са 44 ъма от род Pediococcus.

26.7% belongs to the genus Lactobacillus ssp. In the two mentioned cheeses researchers found Enterobacter faecalis, which was in a higher count in the cheese with moulds (40.0%), and in the cheese without mould has reached 13.6%, but consequently during the ripening period decreased to 3%. Very similar was the trend of L. lactis, which in immature cheese without moulds reached 4.5% of microflora, but its quantity decreased during the storage time. At the contrary, Leuconostoc mesenteroides reached 9.1% in immature cheese without moulds but its number increased during the examined period up to 14.7%. In the cheese with moulds researchers found also Lactobacillus parabuhneri (13.3%) and Lactobacillus bifermentans (6.7%), and in the cheese with moulds the number of L. paracasei was also higher, and L. brevis, L. curvatus and L. casei were also found. In the cheese with moulds Pediococcus acetilactici reached 6.7%, and in the cheese without moulds Pediococcus acetilactici reached 6.7%, and in the cheese without moulds - 18.2%, and the total number of strains which belongs to the genus Pediococcus reached 44 strains.

The presence of Lactobacillus plantarum, Lactococcus lactis, Leuconostoc mesenteroides, Lactobacillus paracasei, Lactobacillus curvatus, Lactobacillus brevis was detected by biochemical analysis from Frece et al., (2016) in the milk, curd and the cheese. The same researchers marked that in the cheese made from cow’s milk Lactococcus lactis and Lactobacillus paracasei, and in the cheese of ewe’s milk and after ripening in animal skin bag - the predominant were Leuconostoc mesenteroides and Lactobacillus plantarum. The researchers made an assumption that some strains of staphylococci (S. xylosus) may have a role in formation of the desirable and distinctive taste and flavor of cheese.

The changes in the trends of lactic acid bacteria which participate in the
В тя микрофлора на тулумско сирене се открив в изследванията на Oksuztepe et al. (2005) и Cakmakci et al., (2008). Cakmakci et al., (2008) установяват в свежото сирене представители на род Enterococcus, Lactobacillus, Streptococcus, Lactococcus и Pediococcus. Поред изследователите през периода на зреење представители на родовете Streptococcus и Lactococcus изчезват, доколку според изследователите през периода на зреење представители на родовете Streptococcus и Lactococcus изчезват, докато според данните на Karagozlu et al. (2009) представители на род Lactococcus се откриват и по време на зреењето, а броят на представители на род Streptococcus дори нараства в периода на зреење (p<0.01). Данните на Cakmakci et al., (2008) показват, че процентът на видовете от род Enterococcus не се изменя, независимо дали сиренето зрее в животинска кожа или в пластмасова опаковка и е преобладаваща микрофлора наред с представители на род Lactobacillus. Аналогични са данните на Tuncer (2009), който изолира 39 вида шамо, от които почти половин (43.58%) са представители на шамо Enterococcus faecium, шамове на Enterococcus faecalis и Enterococcus durans се откриват в еднакво количество - 28.21%. Cakmakci et al., (2008) отбелязват, че някои видове к ото Lactobacillus brevis, Leuconostoc mesenteroides subsp. dextranicum, Pediococcus damnosus и Enterococcus mundtii се изолират с мо от сиренето, което е зрело в пл стм сови от ковки, шамове на Lactobacillus coryniformis и Lactobacillus malafermentans се изолират с мо зрело в козя кожа в периода от 6 до 9 месеца, интересно е зключение на изследователите е, че броят на изолирани шамове Enterococcus faecalis е по-висок в сиренето, което е зрело в пл стм совите от ковки, отколкото в животинска кожа.

Интересно е, че в изследванията на Oksuztepe et al. (2005) и Cakmakci et al., (2008) се откриват в изследванията на Oksuztepe et al., (2005) и Cakmakci et al., (2008). Cakmakci et al., (2008) се откриват в изследванията на Oksuztepe et al., (2005) и Cakmakci et al., (2008). Cakmakci et al., (2008) установяват в свежото сирене представители на род Enterococcus, Lactobacillus, Streptococcus, Lactococcus и Pediococcus. Поред изследователите през периода на зреење представители на родovете Streptococcus и Lactococcus изчезват, докато според изследователите през периода на зреење представители на родовете Streptococcus и Lactococcus изчезват, докато според данните на Karagozlu et al. (2009) представители на род Lactococcus се откриват и по време на зреењето, а броят на представители на род Streptococcus дори нараства в периода на зреење (p<0.01). Данните на Cakmakci et al., (2008) показват, че процентът на видовете от род Enterococcus не се изменя, независимо дали сиренето зрее в животинска кожа или в пластмасова опаковка и е преобладаваща микрофлора наред с представители на род Lactobacillus. Аналогични са данните на Tuncer (2009), който изолира 39 вида шамо, от които почти половин (43.58%) са представители на шамо Enterococcus faecium, шамове на Enterococcus faecalis и Enterococcus durans. Cakmakci et al., (2008) have noticed, that some particular species as Lactobacillus brevis, Leuconostoc mesenteroides subsp. dextranicum, Pediococcus damnosus and Enterococcus mundtii can be isolated only from cheese ripened in plastics, and the strains of Lactobacillus coryniformis and Lactobacillus malafermentans were isolated only from cheese ripened in goat’s skin bag for a period of 6 to 9 months. The interesting observation of the authors is that the numbers of strains Enterococcus faecalis in cheese ripened in plastics were higher than in the cheese ripened in animal skin bag.

Oksuztepe et al., (2005) have published very detailed study which
examined the changes of microflora of savak tulum cheese, made from raw ewe's milk and 90 days ripening period in plastic package.

The researchers isolated in all 851 strains and 783 of it were lactic acid bacteria. Researchers also found that during the first months of cheese ripening the predominant were round shaped bacteria and later rod shaped bacteria prevailed. Among round shaped bacteria the most abundant were strains of Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. lactis, and Leuconostoc mesenteroides subsp. cremoris. Enterococci also was found in very high number – from 19 up to 34% from all of the isolated strains during the ripening.

According to the quantitatively proportion among the different groups of microorganisms in the cheese Karagozlu et al., (2009) estimated equally high number of lactobacilli (7.301 log cfu/g) and streptococci (7.278 log cfu/g), along with a substantially lower number of enterococci (0.176 log cfu/g), but a comparatively high number of yeast (1.623 log cfu/g). The same researches noticed high number of coliform bacteria (5.716 log cfu/g) and even higher count of psychrophilic and lypolitic bacteria (7.000 log cfu/g). Similar were the results of Dinkci et al., (2012) in whose study the number of streptococci (7.28 ±0.20 log cfu/g) and lactobacilli (7.39±0.12 log cfu/g) was almost equal, but on the contrary the researchers found a higher number of yeast and moulds - 6.10 log cfu/g, but a low number coliform bacteria (less than 10 in the gram of the product).

In microflora of bouhezza cheese Zitoin et al., (2011) also found the presence of yeast and moulds (4-5 log cfu/g\(^{-1}\)) and lypolitic bacteria (3 - 4 log cfu/g\(^{-1}\)). According to the opinion of researches the aforementioned two groups of microorganisms had little effect on the
The main pathogen which can be associated with tulum cheese according to Samelis and Kakiuri (2007) is *Listeria monocytogenes*, which was detected in 25% of the samples in their study. The results showed that by direct counting, the quantities of some live cells were lower than 10 CFU/g and some of them were identified as *L. innocua*. The very detailed and expanded study on the presence of *L. monocytogenes* and *Salmonella spp.* in samples of different tulum cheeses was done by Colak et al., (2007), who analyzed 250 samples which have been bought from the markets in Istanbul. The laboratory tests revealed the presence of *L. monocytogenes* in 12 samples (4.8%) and *Salmonella spp.* in 6 (2.4%) samples. The scientific work of Binöl et al., (2012) was aimed not only in detection of pathogens, but also in the detection of some enterotoxins and verotoxins in different local cheeses sold in the Turkey’s markets. Among 25 tulum cheese samples positive for the presence of *Staphylococcus aureus* were 8 samples. *E.coli* was found in 12 of these samples, 1 sample gave positive results even for the presence of *E. coli O157*, 6 of the samples showed the presence of enterotoxin and one sample was positive for verotoxin. Kunduhoglu et al., (2012) also found in tulum cheese *Staphylococcus haemolyticus*, *E. coli*, *Clostridium spp.* and *Eubacterium tenue*. Frece et al., (2016) detected in the tulum cheese staphylococci as *S. xylosus*, *S. aureus* and *S. epidermidis*. Comparative-ly high number staphylococci were found.
лококи к то S. xylosus, S. aureus и S. epidermidis. Исок брой ст. филококи уст новяг т също Karagozlu et al., (2009) - 4.173 log cfu/g. Лед к то уст новяг т по-висок брой н S. aureus (н д 2 log CFU/g) в две трети от изследв ните млек, сиренин и готово сирене Frece et al. (2016) изследв т същите проби з н личи н ст филококов ентеротоксин (SE) и открив т в две от пробите овче сирене ентеротоксин C (SEC).

After the detection of higher number S. aureus (over 2 log CFU/g) in the two third of the tested samples of milk, curd and ripened cheese Frece et al., (2016) broadened the examination of the same samples and made tests for the presence of staphylococcal enterotoxins (SE). Two of the ewe’s cheese samples turned out to be positive for enterotoxin C (SEC).

Because of the presence of some unwanted microorganisms Karagozlu et al., (2009) drew a conclusion that the production of tulum cheese still faced some difficulties in order to produce final standard product, and some of the microorganisms which are found in it can be serious threat to health.

The same researchers thought that such unsafe in microbiological aspects food products shouldn’t be recommended for consumption, but bearing in mind the great popularity of this kind of cheese they expressed the necessity of measures aimed of increasing quality of the product and acceptance of standard technology scheme.

Others researches also expressed the necessity of further experiments on the cheese microflora (Erdogan and Gurses, 2005; Frece et al., 2016).

The scientific researches on the natural microflora of artisan tulum cheese have indicated that starter culture, which can be applied in cheese making technology, should combine both round and rod shaped lactic acid bacteria.

The concluding opinion about the participating species or their exactly quantitative proportion or even any kind of precise composition of the starter culture are still missing, but there are several suggestions about the species which should participate in the starter
The research data clearly indicates that *Lactobacillus plantarum, Lactobacillus casei subsp. casei* and *L. paracasei* should participate in the starter culture for tulum cheese production (Oksuztepe et al., 2005; Kunduhoglu et al., 2012), and also *Lb. parabuhneri* (Erdogan and Gurses, 2005). Because of the presence of an abundant quantity of enterococci in the tulum cheese Erdogan and Gurses (2005), Cakmakci et al., (2008) and Kunduhoglu et al., (2012) have suggested that enterococci species as *E. faecalis, E. faecium* and *E. durans* also can take part in the starter culture combinations. Kunduhoglu et al., (2012) contemplated the necessity of inclusion in the starter culture some additional homofermentative strains as *L. plantarum* and *S. thermophilus*, and Oksuztepe et al., (2005) and *Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. lactis* and *Leuconostoc mesenteroides subsp. cremoris*.

**Sensory characteristics**

Due to specific cheese making process and ripening, tulum cheese has a crumbly texture and doesn’t possess a regular shape or particular size.

According to Hayloglu et al., (2011) the cheese has a white to lightly cream color, high fat contents and a crumbly and semihard texture.

The cheese is dispersible in the mouth and has a buttery and pungent flavor. The color of cheese put in an animal skin bag obtains yellowish color when it comes into contact with the inner surface of the skin, but the inner parts of the cheese retained its white color (Durlu-Özkaya and Gün, 2014). Karagozlu et al., (2009) estimated the quantity of the free fatty acids in *cimi tulum* cheese and found that the most abundant was the quantity of oleic acid (31.73%), followed...
by palmitic acid with 24.19% and myristic acid with 9.32%. The sensory characteristic of cheese variety *divle tulum* depends on the volatile components as kethons, alcohols (mostly 2-butanol and 3-methyl-1-butanol) and different terpenes (Hayaloglu and Karagul-Yuseer, 2011). Hayaloglu et al., (2007) found more than 100 volatile components in the tulum cheese. Among them are 11 organic acids, 16 esters, 12 methylketons, 7 aldehydes, 22 alcohols, 7 sulfur components, 6 terpenes and other 19 components. The main cheese components are short chain fatty acids, 2-butanone and ethanol.

By applying the tests on a point scale from 1 to 7 points about flavor, texture and intensity Zitoin et al., (2011) examined the sensory characteristics of *bouhezza* cheese and defined two major families of odours and aroma characteristics: lactic and animals. The chromatographic examination of *bouhezza* cheese done by Medjoudj et al., (2017) found more than 109 different components and the carboxylic acids, esters, and alcohols are the main classes of the volatile components in the cheese.

### CONCLUSIONS

The growing number of scientific articles and available data about tulum cheese are the indicators for increasing interest towards artisan technology and the influence of entirely natural raw materials and methods which are used in the homemade production. The diversity of materials and methods have an impact on the presence of heterogeneous microflora in both aspects - quantitatively and qualitatively and this microflora has a paramount influence over unique and distinctive taste and flavor of the cheese. The specific cheese appearance, accompanied by a sophisticated combination of aroma and taste substances, is a real prerequisite for
successful marketing at guaranteed price, along with the possibilities of gaining a specific market share and particular group of devoted consumers.

The successful retail, despite the limited volume of cheese production, will facilitate the economic stability of cheese producers and will guarantee preservation of the original artisan cheese technology.

It has to be taken into account that not only the homemade production of cheese but also in small dairy plants can be under the influence of variable and unfixed factors, which can lead to the production of cheese batches with uneven quality and characteristics. This trend sometimes can be accompanied by an elevated thread of presence or development of undesirable microorganisms and pathogens.

Remodeling the homemade methods, in order to meet the requirements of industrial plant scale production will include the introduction of standard processing system and different kind of packaging instead of an animal skin which probably will change the typical characteristics of cheese.

During industrial manufacturing process the unique taste and flavor of cheese can be preserved by suitable starter culture which till now is not composed.

The existing controversial trends, one of which is towards preservation of artisan technology, and the other is towards increasing the product popularity and good economic profit for the producers, can be attenuated by receiving a status according to the European Union scheme: Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) or Traditional Speciality Guaranteed (TSG).
In Turkey, as a country where the cheese is comparatively well-known, the appropriate standard documents about cheese production already exist.

Slow food organization have included the tulum cheese in its collection (the Ark of taste) of interesting and valuable local food products. All aforementioned facts undoubtedly indicate the growing interest, both scientific and economic, towards production of tulum cheese, as well as its spreading popularity.

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Biological effect of selenium supplementation during the pasture period of sheep, reared in some endemic areas of the Western Rhodope Mountain on selenium content in the milk

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SUMMARY

The large number of different sheep species, their wide adaptability to forage quality and high genetic potential, makes possible their widespread dissemination. However, an imbalance of the main biogenic components (selenium, iodine) in mountainous areas could adversely affect the milk production and the daily secretion of essential macro and trace elements through the milk produced during lactation.

This study was conducted with 16 lactating ewe’s from Rhodope Tsigay breed, grown in endemic region of the
Western Rhodope Mountain – village Borino. The animals were divided into two groups - control and deficient group. Feed was prepared according ARC-norms with different amounts of selenium during the experimental period. During the lactating period, the sheep in the control group were additionally supplemented "per os" with 0.25 mg selenium / day in form of NaHSeO₃. Milk samples from both breeds were taken on the 30th and 60th day after the addition of selenium and were compared with the content of selenium at the beginning of the experiment. Low concentrations of selenium in the plant species (Se <60-70 g / kg fodder) during lactation (April-June) affect negatively the concentration of Se in sheep milk. Its amount in the ewe's milk increased reliably as a result of supplementation. Within 60 days, the levels of the element reached a normal values in the control group, while in the deficient animals critical values in the milk (20-30 gSe / l) had been established. The effect of Se-supplementation on average daily secretion of macro- and trace elements was studied, as well as the changes in the milk production during the survey period. Recommendations for the inclusion of selenium supplements for small ruminants, bred in the endemic areas during the grazing period have been proposed.

**Key words:** selenium deficiency, supplementation, ewe's milk, Se-mineral supplements

**INTRODUCTION**

There has been increasing interest in the ewe's milk products in the last several years. Their quality highly depends on the milk performance of the raw milk. The effect of trace element supplementation in the feed ration of different sheep breeds on the milk yield and milk quality during the lactation period has not yet been thoroughly investigated.
The species-specific trace element supply to different sheep breeds and its reaction during the supplementation showed that the results obtained in one genotype cannot be transferred to another, without experimental testing (Angelow et al., 1998; Groppel, 1987; Odjakova et al., 1998; Petrova et al., 1999; Todorova et al., 1993, 1996, 1997). In mountainous areas the established deficiency of basic essential trace elements (selenium, iodine, zinc, cobalt, iron) in the feed ration reflects on the productivity and biological status of sheep (Angelow and Todorova, 1998). Se deficiency influenced negatively the Se transfer in goat and sheep milk (Angelow et al., 1993; Anke et al., 1989; Todorova et al., 1993, 1997). On the other hand, high levels of some macro- and trace elements (Ca, S, Cu) might influence the Se accumulation and led to secondary Se-deficiency in the organism of ruminants (Angelow, 1995; Dragnev et al., 1991). Synergistic effect between Se and I was investigated in rats and sheep (Angelow, 1997; Arthur et al., 1991; Burk, 1994; Delange et al., 1993). Se-deficiency impairs thyroid hormone metabolism by inhibiting the activity of the deiodinases, which convert thyroxine (T4) to the more metabolically active 3, 3'-5 triiodthironine (T3). Se deficiency led to a decrease of the I-contents (27-50%) in the milk and blood serum (Angelow, 2008).

The objective of present study was to establish the effect of Se supplementation to the feed of lactating sheep (Rhodope Tsigai) on the milk yield and properties, Se- and I-content in raw milk and daily Se-I production during the lactation period (60 days).

### MATERIAL AND METHODS

The experiments were carried out with 16 ewes of Rhodope Tsigai breed, divided into two groups. During the grazing period, in depends on vegetation...
RESULTS AND DISCUSSION

The studies in the last 10 years conducted in various mountain regions of Bulgaria have shown that inorganic feed additives (selenium, iodine and zinc) lead to changes in milk yield, fat content and protein content in milk (Odjakova et al., 1998). Generally, the use of organic form of selenium as additives is more effective than inorganic compounds of selenium, as they are biologically more easily digestible (Lyons et al., 2007; Rayman et al., 2008). The significantly lower cost and easy accessibility of inorganic selenium compounds makes them a major source of supplementation. There are little researches into the transfer of the various forms of selenium along the food chain as well as on chemical forms of selenium in human and animal food.

The effect of selenium supplementation on the milk production was investigated during the first 60 days
after the weaning period. Milk yield was tested through individual milk samples, collected during the active pasture period. Data on the milk yield dynamics at the 30th and 60th day after supplementation are presented on Table 1. The amount of milk produced by control and deficient ewe’s differed significantly. The control group produced at any time more milk (209 - 56 ml/day) with natural fat content in comparison to the deficient one (220% and 120%). With advance of lactation the milk yield of both groups had been reduced by 54,4% (342 ± 59 ml/day) and by 16,1% (286 ± 192 ml/day). In this case a specific reaction of the organism depending from the initial biological status of different species is obvious.

Table 1. Effect of selenium supplementation on the daily milk yield of Rhodope Tsigai ewes during the milking period (n1 = 8; 8; n2 = 8; 8)

<table>
<thead>
<tr>
<th></th>
<th>30th day</th>
<th>60th day</th>
<th>Average milk yield during the whole period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(06.May 2013)</td>
<td>(06.June 2013)</td>
<td></td>
</tr>
<tr>
<td>Supplemented group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>750 ± 241</td>
<td>342 ± 59</td>
<td>527 ± 258</td>
</tr>
<tr>
<td>Deficient group</td>
<td>341 ± 157</td>
<td>286 ± 192</td>
<td>366 ± 182</td>
</tr>
<tr>
<td>%</td>
<td>220</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>t - test</td>
<td>P&lt;0,05</td>
<td>P&gt;0,05</td>
<td></td>
</tr>
</tbody>
</table>

* Deficient group=100%; Supplemented group=X%

Selenium deficiency hadn’t any effect on the fat, protein and lactose content of sheep milk during the grazing period (Table 2).

Based on the milk yield and properties of sheep milk at the 30th and 60th day of experiment, it could be calculating the daily secretion of protein, fat and lactose of both group during the whole period. The average daily secretion decreased with the advance of lactation, what reflected on the reduction of milk yield and the alterations in the milk composition? In the supplemented group of the Rhodope Tsygai breed there was a significantly higher average milk yield during the experiment - 152% (Table 2).
Table 2. Effect of selenium supplementation on the milk performance and composition of raw milk during the pasture period ($n_1=16$; $n_2=16$)

<table>
<thead>
<tr>
<th></th>
<th>Deficient group</th>
<th>Supplemented group</th>
<th>%</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Дневна млечност, ml/ден</td>
<td>371</td>
<td>190</td>
<td>565</td>
<td>252</td>
</tr>
<tr>
<td>Daily milk yield, ml/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Млечни мазнини, %</td>
<td>8,11</td>
<td>1,28</td>
<td>7,80</td>
<td>1,17</td>
</tr>
<tr>
<td>Fat content, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Млечен протеин</td>
<td>6,32</td>
<td>0,38</td>
<td>6,24</td>
<td>0,57</td>
</tr>
<tr>
<td>Protein content, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Млечна захар, %</td>
<td>4,56</td>
<td>0,27</td>
<td>4,57</td>
<td>0,17</td>
</tr>
<tr>
<td>Lactose, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Секреция на млечни мазнини, g/day</td>
<td>30,1</td>
<td>14,3</td>
<td>44,1</td>
<td>16,4</td>
</tr>
<tr>
<td>Daily fat secretion, g/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Секреция на млечен протеин, g/day</td>
<td>23,4</td>
<td>11,6</td>
<td>35,3</td>
<td>14,2</td>
</tr>
<tr>
<td>Daily protein secretion, g/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Секреция на млечна захар, g/day</td>
<td>16,9</td>
<td>9,4</td>
<td>25,8</td>
<td>11,9</td>
</tr>
<tr>
<td>Daily lactose secretion, g/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Общ общо сухо вещество, %</td>
<td>19,9</td>
<td>1,5</td>
<td>19,6</td>
<td>1,6</td>
</tr>
<tr>
<td>Total solids, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Сух безмаслен остатък, %</td>
<td>12,0</td>
<td>0,4</td>
<td>11,9</td>
<td>0,5</td>
</tr>
<tr>
<td>Solids-non-fats, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Deficient group=100%; Supplemented group=X%
The difference in selenium concentration in the milk between the two groups increased from day 30\textsuperscript{th} to day 60\textsuperscript{th} from 205\% to 320\%. On the average during the whole period, the deficient animals secreted milk containing 2.55 times less selenium.

Similar results were obtained by calculating the daily Se-secretion during the different sub-periods (Table 4).

### Table 4. Effect of supplementation on the daily selenium secretion via ewe's milk of Rhodope Tsigay breed during the pasture period (µg/day)

<table>
<thead>
<tr>
<th>Group / Period</th>
<th>30\textsuperscript{th} day (06. May 2013)</th>
<th>60\textsuperscript{th} day (06. June 2013)</th>
<th>Daily Se-secretion during the whole period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemented</td>
<td>34.8 ± 9.8</td>
<td>21.2 ± 4.6</td>
<td>28.3 ± 10.5</td>
</tr>
<tr>
<td>Deficient</td>
<td>9.0 ± 4.6</td>
<td>6.1 ± 2.8</td>
<td>7.4 ± 4.0</td>
</tr>
<tr>
<td>%* t-test</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>382</td>
</tr>
</tbody>
</table>

* Deficient group=100\%; Supplemented group=X\%
несуплементирани овци. Редицата секреция на селен през целия период достига 382%.

В сравнение със селена, няма значително понижаване на концентрацията на йод в овчето мляко (Таблица 5).

Таблица 5. Ефект от суплиментацията върху съдържанието на йод в млякото на овце от Родопски Цигай през време на сиенния период (µg/l)

<table>
<thead>
<tr>
<th>Групи / Период</th>
<th>30th day (06. May 2013)</th>
<th>60th day (06. June 2013)</th>
<th>Съдържание на йод в млякото през целия период</th>
</tr>
</thead>
<tbody>
<tr>
<td>Суплементирана</td>
<td>70,7 ± 8,4</td>
<td>60,6 ± 14,6</td>
<td>65,2 ± 12,7</td>
</tr>
<tr>
<td>Дефицитна</td>
<td>72,9 ± 4,3</td>
<td>48,0 ± 6,8</td>
<td>61,6 ± 14,0</td>
</tr>
<tr>
<td>%*</td>
<td>97</td>
<td>126</td>
<td>106</td>
</tr>
<tr>
<td>t-test</td>
<td>П&gt;0,05</td>
<td>П&gt;0,05</td>
<td></td>
</tr>
</tbody>
</table>

* Дефицитна група=100%; Суплементирана група=Х%  
* Deficient group=100%; Supplemented group=X%

Разликите между две групи достигат на 60-ия ден след началото на суплиментация около 26% (p>0,05). Въз основа на добива на млякото при двете групи са установени различни нива в средно-дневната секреция на йод (µg/ден) през целия период (Таблица 6).

Таблица 6. Ефект от суплиментацията върху дневната секреция на йод чрез овчето мляко на Родопски Цигай бройка през време на пасищния период (µg/day)

<table>
<thead>
<tr>
<th>Групи / Период</th>
<th>30th day (06. May 2013)</th>
<th>60th day (06. June 2013)</th>
<th>Дневна секреция на йод през целия период</th>
</tr>
</thead>
<tbody>
<tr>
<td>Суплементирана</td>
<td>53,5 ± 18,6</td>
<td>21,2 ± 7,6</td>
<td>35,9 ± 20,7</td>
</tr>
<tr>
<td>Дефицитна</td>
<td>32,1 ± 13,1</td>
<td>14,0 ± 10,2</td>
<td>23,9 ± 14,7</td>
</tr>
<tr>
<td>%*</td>
<td>167</td>
<td>151</td>
<td>150</td>
</tr>
<tr>
<td>t-test</td>
<td>П&lt;0,05</td>
<td>П&gt;0,05</td>
<td></td>
</tr>
</tbody>
</table>

* Дефицитна група=100%; Суплементирана група=Х%
* Deficient group=100%; Supplemented group=X%

The differences between the two groups reached at the 60th day after the start of the supplementation about 26% (p>0,05). Based on the milk yield of the two groups during the two sub periods, different values in the daily iodine production via milk have been established (Table 6).
ewes received additionally selenium during the whole period, secreted 150% more iodine than animals in the deficient group.

CONCLUSIONS

The investigation with lactating ewe's showed the influence of multi-element deficiency (chronic selenium and suboptimal iodine deficiency) on the milk yield and milk properties, as well as the Se-I content of raw milk and Se- and I-secretion. The imbalance in the Se content during the pasture feeding was in comparison to the other studies relevant and showed the dynamic changes of selenium and iodine in milk significant. The results obtained showed that a correction of Se offer to the rations of lactating sheep was needed.

/ REFERENCES

Influence of selenium and iodine supplementation on the milk yield and selenium and iodine content in the milk during the grazing period of sheep reared in Middle Rhodope Mountain

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SUMMARY

The experiments were carried out with 20 ewes of the Karakachan breed, divided into two groups (2x10). The animals were fed ad libitum on pasture areas with different amounts of selenium and iodine during the grazing period. Complete diet contained low levels of selenium (0.065 mg Se/kg DM) and sub-optimal content of iodine (0.096 mg I/kg DM). The control group received additionally 0.25 mg Se/day as NaHSeO₃ and 0.10 mg I/day as KI during the whole investigated period (90 days). The insufficient Se and marginal iodine offer during lactation period led to decrease of milk production, daily protein and trace
element secretion. From 30.April to 30.June the pasture grass offer about 50% from selenium and 70% from iodine of the animal needs. Deficient ewe’s produced on the average 19% less milk with natural fat content. The protein secretion via milk was reduced by 32% in comparison to the supplemented group. Furthermore, the Se content in the deficient milk and daily Se-secretion were significantly decreased by 178% and 401% during the grazing period. In order to achieve maximum milk production, a mandatory correction of selenium-iodine supply in the lactating sheep farmed in the region of the Middle Rhodopes (Bulgaria) is necessary.

Key words: sheep, Se-deficiency, milk yield, Se-, Zn-, I-content of milk, daily Se-I-secretion

INTRODUCTION

The species-specific trace element supply to different sheep breeds and its reaction during the supplementation showed that the results obtained in one genotype can not be transferred to another, without experimental testing (Anke et al. 1993; Groppel, 1987, 2001; Odjakova et al., 1998; Todorova et al., 1993, 1995; Arthur et al.1991).

A complex evaluation and analyses of plant resources in the mountain area of the Middle Rhodope are the first stage to obtain information about protein and mineral offer through the permanent grassland to ewe populations of the local Karakachan breed.

Data on the mineral composition of the natural pasture vegetation indicated irregular distribution of essential inorganic nutrients, depending on the type of sites, botanical composition of phytocenoses and vegetation stage.
The established database on the local distribution of mineral components related to the specific ecological features of the region, identified the limiting influence of particular elements regarding the nutritional requirements of small ruminants. The implemented research along the nutrient chain of the animals outlined the area as endemic, regarding to some essential elements: selenium and iodine. The insufficient mineral supply to the farm animals reared in the mountain agro-ecosystems required to achieve a balanced nutrition.

Many authors report the need on the systematic control of the nutritional value of grasses during pasture period (April-June) and gave the answer on the biological effect of supplementation (Angelow et al., 2004, 2004a; Arnhold et al., 1993; Chanoine et al., 1993; George and Haenlein, 2006). The addition of necessary essential trace elements along the food chain led to changes in milk properties, some macro parameters and mineral composition of milk and dairy products (Angelow et al., 1993; Angelow and Todorova, 1998; Makaveeva et al., 2004; Petrova et al., 1999).

The aim of the present study is to investigate the effect of selenium and iodine addition in the pasture of Karakachan sheep on milk yield, physicochemical parameters of milk and changes in selenium and iodine levels in the ewe’s milk during the milking period.

**MATERIAL AND METHODS**

The experiments were carried out with 20 ewes of the Karakachan breed, divided into two groups (2x10). he animals were fed ad libitum on pasture areas with different amounts of selenium and iodine during the grazing period. Complete diet contained low levels of selenium (0.065 mg Se/kg DM) and sub optimal content of iodine (0.096 mg I/kg DM). The control group received additionally 0.25 mg Se/day as NaHSeO₃.
mg I/ден като KI през целия изследван период (90 дни). робите от мляко събирани от 30-ти, 60-и и 90-и ден по време на сициния период. Ъдържанните в млякото е определено като се използва томно- борбионната система с хидридно генериран пл зм (AGILENT 7500c ICP-MS). определението йод в млякото се взема 1 г сухо вещество от лиофилизирано мляко и се р в ри в 10 ml - 0,07 n TMAH, последвжно хомогенизиране на 2 мин чрез ултразвуков хомогенизатор. пробите се разреждат до 25 ml и се измерват непосредствено в ICP-MS (Agilent 7500c) с Te като вътрешен стандарт. всички резултати се изразяват като средна стойност ± стандартно отклонение и се сравняват чрез стандартен t-тест.

РЕЗУЛТАТИ И ОБСЪЖДАНЕ

RESULTS AND DISCUSSION

The established imbalances of basic essential elements (Se and I) in the flora in the investigated area could affect negatively the milk production during the pasture period. Influence of the Se- and I-supplementation on the milk performance and composition of raw milk during pasture period was tested through individual and average milk samples, collected during the active pasture period. Data on the milk yield dynamics during milking period on the pasture are presented on Table 1.

Table 1. Effect of selenium and iodine supplementation on the daily milk yield of Karakachan ewes during the pasture period

<table>
<thead>
<tr>
<th>Daily milk yield, ml/day</th>
<th>30th day (30.April 2013)</th>
<th>60th day (30.May 2013)</th>
<th>90th day (30.June 2013)</th>
<th>Average milk yield during the whole period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemented group</td>
<td>991 ± 125</td>
<td>796 ± 122</td>
<td>499 ± 165</td>
<td>771 ± 243</td>
</tr>
<tr>
<td>Deficient group</td>
<td>838 ± 99</td>
<td>651 ± 101</td>
<td>374 ± 129</td>
<td>649 ± 212</td>
</tr>
<tr>
<td>%</td>
<td>118</td>
<td>122</td>
<td>133</td>
<td>119</td>
</tr>
<tr>
<td>t-test</td>
<td>P&gt;0,05</td>
<td>P&lt;0,05</td>
<td>P&lt;0,05</td>
<td>P &lt; 0,05</td>
</tr>
</tbody>
</table>

* Supplemented group = 100 %; Deficient group = %
В началото на пасищния период средният дневен добив на мляко при суплементирана група е 991±125 ml.

Крайно добивът на мляко се намалява до 499±165 ml (с около 50%).

При несуплементирани овце добивът на мляко намалява от 838±99 ml до 374±129 ml (55%) в края на дойния период. Най-големи разлики са наблюдавани в края на изследвания период (33%). Суплементираните овце имат по-висока млечност през целия изследван период и разликата между двете групи достига 19% (p<0.05).


Таблица 2. Ефект от добавката на селен и йод върху показателите и състава на суровото мляко през пасищния период (n1=30; n2=30)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>deficient group</th>
<th>supplemented group</th>
<th>p</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>daily milk yield, ml/day</td>
<td>649±212</td>
<td>771±243</td>
<td>&lt;0.05</td>
<td>119</td>
</tr>
<tr>
<td>fat content, %</td>
<td>6.55±1.52</td>
<td>5.85±2.18</td>
<td>&gt;0.05</td>
<td>90</td>
</tr>
<tr>
<td>protein content, %</td>
<td>5.79±0.79</td>
<td>5.71±1.14</td>
<td>&gt;0.05</td>
<td>100</td>
</tr>
<tr>
<td>lactose, %</td>
<td>4.52±0.73</td>
<td>4.36±0.75</td>
<td>&gt;0.05</td>
<td>94</td>
</tr>
<tr>
<td>daily fat secretion, g/day</td>
<td>41.8±14.6</td>
<td>42.5±17.9</td>
<td>&gt;0.05</td>
<td>103</td>
</tr>
<tr>
<td>daily protein secretion, g/day</td>
<td>34.9±17.2</td>
<td>43.7±16.6</td>
<td>&lt;0.05</td>
<td>132</td>
</tr>
<tr>
<td>daily lactose secretion, g/day</td>
<td>27.4±12.6</td>
<td>33.9±12.8</td>
<td>&lt;0.05</td>
<td>127</td>
</tr>
<tr>
<td>total solids, %</td>
<td>17.8±1.9</td>
<td>16.9±2.9</td>
<td>&gt;0.05</td>
<td>95</td>
</tr>
<tr>
<td>solids-non-fats, %</td>
<td>11.4±0.7</td>
<td>11.1±1.1</td>
<td>&gt;0.05</td>
<td>98</td>
</tr>
</tbody>
</table>

* Deficient group=100%; Supplemented group=X%
42

Table 3. Effect of Se-I supplementation on the milk fat content of Karakachan ewe’s during the pasture period (%)

<table>
<thead>
<tr>
<th>Milk fat, %</th>
<th>30&lt;sup&gt;th&lt;/sup&gt; day (30.April 2013)</th>
<th>60&lt;sup&gt;th&lt;/sup&gt; day (30.May 2013)</th>
<th>90&lt;sup&gt;th&lt;/sup&gt; day (30.June 2013)</th>
<th>Average milk fat during the whole period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemented group</td>
<td>5,51 ± 2,56</td>
<td>5,05 ± 0,87</td>
<td>7,10 ± 2,38</td>
<td>5,85 ± 2,18</td>
</tr>
<tr>
<td>Deficient group</td>
<td>6,51 ± 1,20</td>
<td>5,82 ± 1,22</td>
<td>7,65 ± 1,83</td>
<td>6,55 ± 1,52</td>
</tr>
<tr>
<td>%</td>
<td>85</td>
<td>87</td>
<td>93</td>
<td>89</td>
</tr>
<tr>
<td>t - test</td>
<td>P&gt;0,05</td>
<td>P&gt;0,05</td>
<td>P&gt;0,05</td>
<td>P &gt; 0,05</td>
</tr>
</tbody>
</table>

*Mеѳицитн груп =100%; уплементиран груп = %
*Deficient group=100%; Supplemented group=X%
The difference in selenium concentration in the milk between the two groups increased from day 30\(^{th}\) to day 90\(^{th}\) from 181\% to 597\%. On the average during the whole period, the deficient animals secreted milk containing 3.8 times less selenium.

Similar results are obtained by calculating the mean daily secretion during the different sub-periods (Table 5).
Table 5. Effect of supplementation on the daily selenium secretion via ewe’s milk of Karakachan breed during the pasture period (µg/day)

<table>
<thead>
<tr>
<th>Групи / Период</th>
<th>30th day (30.April 2013)</th>
<th>60th day (30.May 2013)</th>
<th>90th day (30.June 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Суплементирани</td>
<td>46,4 ± 9,8</td>
<td>54,4 ± 11,8</td>
<td>43,7 ± 17,8</td>
</tr>
<tr>
<td>Дефицитни</td>
<td>21,7 ± 6,0</td>
<td>11,8 ± 2,0</td>
<td>5,4 ± 2,2</td>
</tr>
<tr>
<td>%* t-test</td>
<td>P&lt;0,001</td>
<td>P&lt;0,001</td>
<td>P&lt;0,001</td>
</tr>
</tbody>
</table>

* Дефицитна група = 100%; Суплементирана група = X%

Se-I supplemented animals secreted during the different sub-periods from 2,14 to 8,09 told more selenium in comparison to the deficient ewes. The differences between two groups on the Se-secretion during the whole period reached 350%.

Table 6. Effect of supplementation on the iodine content in the milk of Karakachan ewe’s during the pasture period (µg/l)

<table>
<thead>
<tr>
<th>Групи / Период</th>
<th>30th day (30.April 2013)</th>
<th>60th day (30.May 2013)</th>
<th>90th day (30.June 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Суплементирани</td>
<td>139,2 ± 67,5</td>
<td>109,9 ± 25,4</td>
<td>155,5 ± 41,4</td>
</tr>
<tr>
<td>Дефицитни</td>
<td>151,4 ± 37,4</td>
<td>107,4 ± 31,5</td>
<td>142,0 ± 31,5</td>
</tr>
<tr>
<td>%* t-test</td>
<td>P&gt;0,05</td>
<td>P&gt;0,05</td>
<td>P&gt;0,05</td>
</tr>
</tbody>
</table>

* Дефицитна група = 100%; Суплементирана група = X%

Compared to selenium, there was no significant increase in the iodine concentration of ewe’s milk (Table 6). The differences between the two groups reached at the 90th day after the start of the supplementation about 10% (p>0,05). Based on the milk yield of the two
groups during the three sub periods, different values in the daily iodine secretion via milk have been established (Table 7).

<table>
<thead>
<tr>
<th>Group / Period</th>
<th>30th day (30.April 2013)</th>
<th>60th day (30.May 2013)</th>
<th>90th day (30.June 2013)</th>
<th>Daily I-secretion during the whole period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemented</td>
<td>133,6 ± 58,5</td>
<td>89,1 ± 31,7</td>
<td>76,7 ± 27,4</td>
<td>101 ± 48</td>
</tr>
<tr>
<td>Deficient</td>
<td>124,9 ± 25,0</td>
<td>69,6 ± 21,7</td>
<td>51,5 ± 18,4</td>
<td>85 ± 38</td>
</tr>
<tr>
<td>%* t-test</td>
<td>P&gt;0.05</td>
<td>P&gt;0.05</td>
<td>P&lt;0.05</td>
<td>P&gt;0.05</td>
</tr>
</tbody>
</table>

* Deficient group=100%; Supplemented group=X%

The differences between the supplemented and non-supplemented group varied from 7 to 49%. The ewes received additionally Se- and I during the whole period, secreted 18% more iodine than animals in the deficient group.

CONCLUSIONS

The investigation with lactating ewe's showed the influence of multielement deficiency on the milk yield and milk properties, as well as the Se-I content of raw milk and Se- and I-secretion. The dynamic of the essential inorganic nutrients of ewes' milk and the imbalances in the Se and I content during the pasture feeding was higher than some reference values of different authors in experiments with sheep, goats and cows (Anke and Groppel, 1987; Beate Heseker and Heseker, 1999; Council Directive 92/46/EEC, 1992; Davis and Mertz, 1986; Drobner, 1997; Hurley and Keen, 1987; Heeschen, 1998).
REFERENCES


Influence of the season of obtaining on the quality of boar semen

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The effect of season on ejaculate volume (cm³), concentration (x 10⁶/cm³), motility (%) and pH of the semen of hybrid boars kept in a massive building, cement floor and free access to food and water was investigated.

Studied 52 ejaculates obtained from 5 of the male age 12 to 24 months during the period March 2013 - April 2014 grouped by seasons: winter (January, February, March), Spring (April, May, June), summer (July, August, September) and autumn (October, November, December). It is established increasing the concentration of sperm is established in the winter and spring (P≤0.001), and the volume - in the summer (P≤0.001). The most active spermatozoa in the ejaculate are those obtained in winter (P≤0.001). Differences with respect to the pH of the semen in different seasons have been recorded. By increasing the volume of sperm is not always increases and the concentration of spermatozoa.

SUMMARY
о-голямо влияние върху изследвания ните
пок з тели н сперм т им т темпер ту-
р т и относителн т вл жност отколкото
продължителност т и светлинния ден.

ключови думи: нерези, сперм,
сезон, температур, вл жност,
продължителност и светлинния ден

ролишлените технологии н
отглежд не в свиневъдството н л г т
използв нето изкуствено осеменя-
в не н свинете-м йки. ов изискв
отглежд не н здр ви и с един генетични
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се използв т дълго време к то спермо
производители. вторито н сред т
с неотменен и съпътств щ елемент от
екологични фон н животните, които
много често мог т д се превърнат т в
стресф ктор. тов и Kogan (1983)
допълв , че живот н всеки орг низъм
е непрекъсн т процес н д пт ция.

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но върху обмян т н веществ т,
топло- и г зообмен , здр вето, продук-
тивностт , репродукцият и редиц
други функции н орг низм (Plyashtenko
and Hohlova, 1976; Petkov et al., 1979;
Bildirev et al., 1989; Kunavongkut et al.,
2005; Tolon et al., 2008). поред Love
(1981) температур т и интензивностт
н светлин т влият върху секрецият
н FSH, чрез него н тестостерон , в
результат н т н блюда в т
промени в р змерите н тестисите и
к честото н сперм т. ручув йки
сезонния ефект н светлин т върху
нерези вторит уст новав , че н м
л ението н дневн т светлин през зим
т и есене им стимулир щ ефект
върху репродуктивн т им функция.

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рех в космен покрив според Kelly
and Curtis (1978) с причин з ниск т
устойчивост н нерезите към високите
летни темпер тури, особено в съчет-
ние със силн слънчев р ди ция.

and relative humidity have greater
influence on the examined indicators of
sperm than duration of light day.

Key words: boars, semen, season,
temperature, humidity, duration of the light
day

INTRODUCTION

The industrial breeding
technologies in pig-breeding necessitate
the use of artificial insemination of sows.
This requires breeding of healthy boars
with valuable indicators, which can be
used as sperm producers for a long time.
The factors of the environment are
irrevocable and concomitant element of
the ecologic background of animals,
which factors can often turn into stress
factors. That is why Kogan (1983) also
adds that the life of each organism is a
permanent process of adaptation.

The influence of the season, with its
complex of interrelated and interactive
factors, has a direct influence on
metabolism, heat exchange, gas
exchange, health, productivity,
reproduction, and a number of other
functions of the organism (Plyashtenko
and Hohlova, 1976; Petkov et al., 1979;
Bildirev et al., 1989; Kunavongkut et al.,
2005; Tolon et al., 2008). According to
Love (1981), the temperature and the
intensity of light have influence on the
secretion of FSH, and, through it, on the
testosterone, as a result of which changes
in the size of the testicles and the quality
of sperm is observed. While studying the
seasonal effect of the light on the boars
the author deduces that the reduction of
daylight in winter and autumn has a
stimulating effect on their reproductive
function.

According to Kelly and Curtis
(1978), the poor development of sweat
glands and the loose hair cover are the
reason for the low tolerance of boars to
the high summer temperatures, especially
in combination with strong solar radiation.
Correa et al., (1999) establishes that the low temperatures of the environment do not have influence on sperm production or on the quality of the sperm. According to the data of Petkov et al., (1979); Love (1981), and Silva et al., (2004), the conditions of overcooling or overheating are a reason for over-expenditure of fodder, disturbed growth, disturbed sperm genesis and quality of the sperm. Other authors, like Onegov et al., (1977) and Bildirev and Brachkova (1986) add that when the amplitude of moisture is 30% over the optimal one, its negative influence is observed on the development, the growth, and the normal sperm genesis of boars. O'Brien et al. (1989) conclude that the level of such stressful influences and their effect on the health and productivity of pigs is defined not only by the values of each hygiene indicator but also by the time of their effect.

All of the above-mentioned statements motivate us to study the influence of the season of obtaining on the quality of boar semen.

**MATERIAL AND METHODS**

We conducted the studies on boars bred in a brick building with wooden roof structure, with internal and external lime and sand putty, and a cement floor, in the area around the town of Plovdiv, in the period between March 2013 and April 2014. The building is situated east-westwards, and its windows are mounted on the southern longitudinal wall. We measured the internal and external temperature and the relative humidity of the building with weekly thermo-hygrometer and controlled it with Assmann psychrometer; the intensity of lightness was measured with light meter PU 320. The measurements in the building were performed in the habitat of the animals.

We analyzed the features of climate and geography of the area in accordance to the data of the agrometeorological
Results and Discussion

The use of breeding animals requires knowledge of their physiological and biological features, and of their possibility to be influenced by the various factors of the environment. That is why, particular attention in boar breeding is to be paid to the factors of the production environment, which factors, through their permanent variation, have stimulating effect on their adaptation mechanisms and help for the preservation of their health and productivity (Hristev, 2007).

The average values of temperature and the relative humidity, corresponding to the four seasons of the year, are presented in Figure 1, while Table 1 shows some of the biological parameters of the sperm of the boars in the same seasons.
Fig. 1. Mean seasonal outdoor temperature (° C) and relative humidity (%) for the period March 2013 - April 2014

Table 1. Seminal characteristics of terminal boars obtained in different seasons

<table>
<thead>
<tr>
<th>Season</th>
<th>Volume, cm³</th>
<th>Concentration, x 10⁶/cm³</th>
<th>Motility, %</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Лято/Summer</td>
<td>422.7±19.5</td>
<td>277.3±20.0</td>
<td>71.4±0.8</td>
<td>8.0</td>
</tr>
<tr>
<td>Есен/Осен</td>
<td>270.0±28.9</td>
<td>400.0±29.7</td>
<td>71.0±1.1</td>
<td>8.0</td>
</tr>
<tr>
<td>Зима/Зима</td>
<td>344.6±17.9</td>
<td>492.3±18.4</td>
<td>82.3±0.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Пролет/Весна</td>
<td>313.0±13.5</td>
<td>463.0±13.8</td>
<td>81.9±0.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>

The one-year control of the microclimatic factors deduced that the average temperature of the air within the building is 5.7 °C in winter (with min - 2.0 and max 15.0), in spring it is 11.2°, in summer – 28.8° (with min 15.4 and max 32.7°), and in autumn – 7.7°. The average relative humidity is around 70% (with min 45% and max 100%). The airflow is the lowest in summer – 0.18 m/s and it is highest in winter – 0.31 m/s. It has an intermediate value during the
The hygiene and energy assessment of the building, conducted by Hristev and Zapryanova (2014) proved that without additional heating in winter and mechanical ventilation in winter and summer, boars are expected to have over-expenditure of fodder and reduced reproduction indicators.

The average duration of daylight in winter was around 10 hours, in spring – 12,5h, in summer – 14,5h, and in autumn – 12,3h. The measured intensity of natural light within the building fluctuates between 6 and 60 lux, which is lower than the permissible hygiene limit (75 lux). According to Love (1981), the reduced intensity of light in winter and autumn has a stimulating effect on the reproductive function of boars.

Our studies did not find any significant dependence between the studied biological features of the sperm from boars and the duration of the daylight. In the complex presentation of the temperature, the respective humidity, and the duration of the day light, combined in ‘Season’, showed a strongly expressed effect on the studied indicators of the sperm.

The results of our studies showed that successful adaptation is induced between the organism of the boars and the environment.

However, during the periods with sharper changes of the temperature and light factor, at the time of the processes of permanent homeostatic condition of the organism, changes are observed in some of the biological features of the sperm (Table 1). A number of authors, like Love (1981), Claus and Weiler (1985), Kozdrowski and Dubiel (2004), Rivera et al. (2005), Tolon et al. (2008), Knecht et al. (2014) also state of similar changes in the volume, concentration, and
significant differences in the concentration of sperm in the different seasons were found, as they are well expressed in winter and summer ($P \leq 0.01$). We found the highest number of sperms in winter ($P\leq 0.001$), and the lowest – in summer. Malinova and Nikolov (2015) came to a similar conclusion with bulls. Regarding the volume of the ejaculate, we established that it is the lowest in spring, and mostly in autumn, and it is the highest in summer ($P \leq 0.001$). We did not find any significant differences between the total number of sperms and the number of living sperms in the ejaculate during the different seasons.

According to Rivera et al. (2005) and Knecht et al. (2014), the temperature and the relative humidity of the air have a greater influence on the examined indicators than the duration of the daylight. This conclusion of the authors was also confirmed by our studies, which established the lowest number and poor motility of the sperms in summer. The conclusion made by Bildirev et al., (1989); Tolon et al., (2008) и Flowers (2008) also confirm the opinion that the temperature stress resulting from the high temperatures in summer, has a negative effect on the quality of boar sperm. The same result was observed by Kozdrowski and Dubiel (2004) with wild boars which inhabit a permanently changing environment during the whole year.

The season is a constellation of multiple changes of physical environmental changes like temperature,
humidity, light, airflow, etc. They are able to show both their complex (seasonal) and their individual influence on the quality and quantity of the sperm obtained by boars. Learning about these dependencies will give a basis for the establishment and application of appropriate care with view to preserving their reproductive ability for a longer period of time.

CONCLUSIONS

1. The low temperatures and high humidity of air in winter and autumn have a stimulating effect on the concentration and motility of sperms ( ≤0,001).

2. The high summer temperatures create conditions of overheating and thermal stress in boars, which results in the reduction of the number of sperms and of their motility, regardless of the fact that the total volume of sperm increases ( ≤0,001).

REFERENCES


