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Comparative Study of the Amount of Macro- And Microelements in the Content of Different Muscles of Lambs and Kids

Bursa S. Jafarli

Azerbaijan State Agrarian University, Ganja, Azerbaijan
***Corresponding author:** bursa96@mail.ru

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ABSTRACT

In the western region of the Republic of Azerbaijan, in the city of Ganja and its surrounding areas, the carcasses of Bozakh lambs and local kids bred on natural pastures were involved in the research. The samples were taken from the musculus longissimus dorsi, triceps brachii muscle, and biceps femoris muscle from chilled carcasses; the amount of nitrogen in their content was determined by the Keldal method and the amount of macro- and microelements in an atomic absorption spectrophotometer. The obtained experimental materials showed that on meat samples taken from the musculus longissimus of dorsi, the amount of calcium in kid meat was 80.96%, significantly ($P<0.01$) higher compared to lamb meat, and the amount of zinc was 31.5% ($P<0.05$) higher than in goat meat. The amount of phosphorus, potassium, sodium, and copper in lamb meat was significantly higher than in kid meat. The quantitative indicator of nitrogen in the triceps brachii muscle of kids is equivalent to 115.4% ($P<0.01$), and the quantitative value of sodium is approximately 3 times ($P<0.01$) higher than that in lamb meat. On the contrary, the amount of calcium in lamb meat was 59.1% ($P<0.05$), the amount of zinc was more than 2 times ($P<0.05$), and the concentration of copper was more than 4 times ($P<0.01$) higher than its indicators of kid meat. The amount of nitrogen in kid meat on the biceps femoris muscle was 68.75% ($P<0.05$), and the amount of calcium was more than 2.5 times ($P<0.01$) than the indicator of lamb meat. In samples taken from the lamb meat, the amount of iron was more than 2 times ($P<0.01$), the concentration of copper was 4 times ($P<0.01$), and the amount of zinc was 2 times ($P<0.05$) higher than the indicators of the samples taken from the kid meat.

Key words: Lamb, Kids, *Longissimus dorsi*, *Triceps brachii*, *Biceps femoris*, Macroelements, Microelements.

INTRODUCTION

Kid and lamb meat has been used as traditional food products in Azerbaijan since ancient times. Kid meat is of good quality and has a delicate taste. Its composition is rich in phosphorus, sulfur, copper, iron, and calcium. Kid meat can compete with veal and lamb (Niedziółka et al. 2009). The world production of kid and lamb is about 4.9% of the total meat production. Although the production of this meat has increased by 2.6 million tons in some countries, there is a shortage in European countries (FAOSTAT 2008).

According to its chemical composition, mutton comprises proteins, fats, extractive substances, mineral substances, enzymes, vitamins, carbohydrates, water, and other nutrients.

The composition of mutton contains macro and microelements (Ca, P, Na, K, Cl, J, Zn, Co, Cu, Ni, Fe, Mn, Mo, F, S, Se, etc.), vitamins (B1, B2, B3, B6, B12, A, K, E, D, biotin, folic acid, etc.), as well as rich in other biologically active substances. Therefore, it has a stimulating effect on the activity of the immune system, cardiovascular system, and central nervous system (Belhaj et al. 2003; Perelló et al. 2008; Niedziółka et al. 2012; Joyce et al. 2016; Jalladov et al. 2020). So, in addition to the high content of protein and lecithin, lean mutton (usually a young animal) is easily absorbed by the body and is useful for diabetics due to its low carbohydrate and cholesterol content (Przybylski et al. 2017). As it is rich in iron element and vitamin B12, it is recommended to be consumed, especially during iron deficiency anemia. The B group vitamins contained in it regulate the function of the central nervous system (Knight et al. 2020; Xiang et al. 2022). The low content of harmful cholesterol in meat also regulates the activity of the cardiovascular system and prevents atherosclerosis. Consumption of this type of

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meat during pregnancy has a positive effect on the development of the fetus. Because the content of mutton is rich in folic acid. Regularly consumed mutton accelerates various biochemical processes and mobilizes the body's defense system (Perelló et al. 2008; Veli et al. 2019; Fan et al. 2019).

The export of meat products from many countries is decreasing due to the pollution of the environment, feed, and water, as well as the higher-than-normal level of chemical elements in meat products (Kasap et al. 2017; Xing et al. 2019). The research has determined it conducted so far that the amount of some elements in the meat and organs of slaughtered animals is much higher than the physiological norm (de Arujo et al. 2017; Schweinzer et al. 2017; Egigba et al. 2018; Zhang et al. 2020; Derar et al. 2022). The amount of chemical elements in the tissues of animals varies depending on their age, sex, and type of tissue (Johnson et al. 1995).

Taking into account all the above, at this stage of our research, we aimed to comparatively study the amount of some micro- and macroelements in the content of lamb and kid meat.

MATERIALS AND METHODS

In the western region of the Republic of Azerbaijan, in the city of Ganja and its surrounding areas, the carcasses of Bozakh lambs and local kids bred on natural pastures were involved in the research. In one of the slaughterhouses of Ganja city, lambs and kids of medium fatness, three heads each, with approximately the same live weight (about 17kg), were selected. The selection was made depending on the daily slaughter per unit of sheep. They were cut, according to Mussulman Shariat. After slaughter, a veterinary-sanitary inspection was conducted by a veterinary specialist of the Food Safety Agency of the Republic of Azerbaijan. Certificates were presented to us that all six carcasses were fit for food. After that, the animal carcasses were weighed, and the weight of the not chilled carcasses was determined. After that, we divided the carcasses into two parts and placed them in refrigerators at a temperature of +5°C for 36hrs. The samples were taken from the musculus longissimus of the dorsi, triceps brachii muscle, and biceps femoris muscle from chilled carcasses. The amount of nitrogen in their content was determined by the Keldal method and the amount of macro- and microelements in an atomic absorption spectrophotometer. Statistical analysis formulation was carried out using the software SPSS version 20.

RESULTS AND DISCUSSION

Experimental materials reflecting the amount of macro- and microelements in meat samples taken from the musculus longissimus dorsi of lamb and kid carcasses are shown in Table 1.

As can be seen from Table 1, the amount of calcium in kid meat is 80.96% (P<0.01), and the amount of zinc is 31.5% (P<0.05) higher than in lamb meat. The amount of phosphorus, potassium, sodium, and copper in lamb meat is 49.9% (P<0.05), 7.98%, 3.09%, and 85.7% (P<0.01), higher than in kid meat, respectively. However, as can be seen, statistical differences are recorded for the amount of phosphorus and copper. Sodium and zinc are important elements for the body. The high amount of these in kid meat indicates the high quality of this meat. The amount of copper and phosphorus in lamb meat is high, which can be considered their genetic characteristic. Because, genetically, for sheep to produce wool, phosphorus and copper exchange in their body should be intensive enough.

Hoffman et al. (2003) also observed that the amount of copper in lamb meat is higher than that of kid meat. Johnson et al. (1995), and Niedziółka et al. (2009) have also proven with their research that the amount of calcium and zinc in the content of kid meat is higher than that of lamb meat. The results of the mentioned studies are in good agreement with our results.

Thus, a comparative analysis of the amount of macro- and microelements in the content of the musculus longissimus of dorsi in lamb and kid carcasses shows that compared with the lamb meat, the amount of calcium in kid meat is 80.96% (P<0.01) and the amount of zinc is 31.5% (P<0.05) higher. The amount of phosphorus and copper in lamb meat is 49.9% (P<0.05) and 85.7% (P<0.01), higher than that of kid meat, respectively.

All the indicators, as mentioned earlier, were also determined in the samples taken from the triceps brachii muscle. The received experimental materials are given in Table 2.

Table 1: Comparative study of the amount of macro- and microelements in the musculus longissimus dorsi of lambs and kids.

Indicators	Units	Lamb meat	Kid meat
Nitrogen (N)	%	0.32±0.06	0.35±0.02
Phosphorus (P_2O_5)	mg/kg	14.5±1.67*	9.67±0.34
Potassium (K_2O)	mg/kg	3059.3±67.3	2833.3±74.3
Calcium, Ca	mg/kg	263.7±8.97	477.2±12.77**
Magnesium, Mg	mg/kg	154.7±4.3	153.8±1.76
Sodium, Na	mg/kg	922.2±28.5	894.6±19.63
Iron, Fe,	mg/kg	5.94±0.73	5.5±0.13
Copper, Cu	mg/kg	0.27±0.04**	0.07±0.006
Zinc, Zn	mg/kg	8.76±0.66	11.52±1.79*
Manganese, Mn	mg/kg	0.33±0.14	0.26±0.04

Note: *P<0.05; ** P<0.01

Table 2: Comparative study of the amount of macro- and microelements in the triceps brachii muscle of lambs and kids.

Indicators	Units	In lamb meat	In kid meat
Nitrogen (N)	%	0.13±0.03	0.28±0.01**
Phosphorus (P_2O_5)	mg/kg	7.97±1.01	6.17±0.42
Potassium (K_2O)	mg/kg	2439.3±107.7	2764.0±83.3
Calcium, Ca	mg/kg	450.7±38.8	283.3±8.8*
Magnesium, Mg	mg/kg	134.7±16.7	146.4±3.43
Sodium, Na	mg/kg	527.5±29.2	1555.3±26.5**
Iron, Fe	mg/kg	8.34±1.23	7.53±0.22
Copper, Cu	mg/kg	0.86±0.05	0.20±0.01**
Zinc, Zn	mg/kg	26.3±0.83	11.49±1.01*
Manganese, Mn	mg/kg	1.03±0.01	0.07±0.008

Note: * P<0.05; ** P<0.01.

Analyzing the data, it can be seen that the main differences in the samples taken from the triceps brachii muscle of lambs and kids are recorded on the amount of nitrogen, potassium, calcium, and magnesium. The

amount of nitrogen in the triceps brachii muscle of kids is 115.4% (P<0.01), and the amount of sodium is about 3 times (P<0.01) higher than the same indicator of lamb meat. On the contrary, the amount of calcium in lamb meat is 59.1% (P<0.05), the amount of zinc is more than 2 times (P<0.05), and the concentration of copper is more than 4 times (P<0.01) higher than its indicators of kid meat. Cetin et al. (2012) noted that the amount of copper and zinc in lamb meat is higher than that of kid meat. In another study conducted on goats in Nigeria (Okoye and Ugwu 2010), it was proved that the high amount of cadmium, copper, and zinc in the meat hurts the quality of the meat. Also, the permissible amount of the mentioned elements in goat meat was analyzed in these experiments. This indicator was 0.07-3.08mg/kg for cadmium, 26.36-398.16mg/kg for copper, and 131.5-417.0mg/kg for zinc. As can be seen, the results obtained for copper and zinc in our experiments are many times lower than the indicators in the mentioned data. This suggests that the amount of microelements considered harmful in the meat of lambs and kids grown in the western region of the Republic of Azerbaijan is much lower than the permissible limit. Schweinzer et al. (2017) studied the macro- and microelement status of animals in 16 sheep and 4 goat farms located in the mountainous regions of Austria. The studies have proven that the amount of potassium, molybdenum, and iron in the blood samples of sheep and goats raised on these farms is below the norm, and the amount of zinc is above the requirement.

Thus, in our experiments, the total amount of macro- and microelements in the meat samples taken from the triceps brachii muscle of lamb and kid carcasses is slightly lower than the indicators mentioned in the literature, which the low amount of those substances in the soil and plant cover of the western regions of Azerbaijan can explain. As for the difference between these elements in lamb and kid meat, as already mentioned above, the main statistical differences are recorded in the amount of nitrogen, potassium, calcium, and magnesium. The amount of nitrogen in the triceps brachii muscle of kids is 115.4% (P<0.01), and the amount of sodium is about 3 times (P<0.01) higher than the same indicator of lamb meat. On the contrary, the amount of calcium in lamb meat is 59.1% (P<0.05), the amount of zinc is more than 2 times (P<0.05), and the concentration of copper is more than 4 times (P<0.01) higher than its indicators of kid meat.

The same studies were carried out on meat samples taken from the biceps femoris muscle of lamb and kid carcasses. The results of those experiments are reflected in Table 3.

The analysis of experimental materials obtained for the biceps femoris muscle shows that the main statistical differences are observed in the amount of nitrogen, calcium, iron, copper, and zinc elements. The amount of nitrogen in kid meat is 68.75% (P<0.05), and the amount of calcium is more than 2.5 times (P<0.01) higher than that of lamb meat. In samples taken from the lamb meat, the amount of iron is more than 2 times (P<0.01), the concentration of copper is 4 times (P<0.01), and the amount of zinc is 2 times (P<0.05) higher than the indicators of the samples taken from the kid meat.

L'opez Alonso et al. (2005) determined the amount of copper and zinc in meat, liver, and kidney samples of young cattle from farms in Galicia, Spain. In these experiments, the amount of copper in the liver was determined as 49.9 and 36.6mg/kg, in the kidneys as 4.27 and 3.63mg/kg, and in the muscle as 0.649 and 1.68mg/kg. The amount of zinc was 46.3 and 52.5mg/kg in liver samples, 14.2 and 20.7mg/kg in kidneys, and 47.3 and 52.5mg/kg in muscle. The results obtained for copper in our experiments are in good agreement with the noted data. However, our experimental materials for zinc show that the amount of zinc in our studies is lower than the indicators given in many literature data. As already mentioned, the amount of zinc in our soil and plants is low.

In another study (Junkuszew et al. 2020), the chemical composition and amount of fatty acid of meat in samples taken from the biceps femoris muscle of lambs and sheep were studied. It was determined that the amount of nitrogen (protein content) in lamb meat is higher and of higher quality. When comparing the content of fatty acids, it was determined that the amount of polyunsaturated fatty acids are higher in lamb meat. Therefore, the authors concluded that young lamb meat is more dietary and plays an important role in the human diet. Zhang et al. (2020) studied the microelement requirements of lambs with a live weight of 35-50kg. It was noted that the need for manganese, iron, zinc, and copper in lambs with a live weight 35kg is 0.86, 70.41, 33.46, and 4.31mg/mL, respectively. In lambs weighing 50kg, these indicators were 0.93, 68.40, 35.20, and 4.15mg/kg for manganese, iron, zinc, and copper, respectively. In these studies, it is also noted that the iron requirements of lambs are much higher than the requirements given in the NRC data. Derar et al. (2022) analyzed the microelement status of sheep and goats with reproductive problems. The concentration of manganese, selenium, iron, and zinc was determined in the blood samples of the animals. It has been proven that the concentration of selenium, iron, and zinc in the blood of sheep and goats with ovarian problems is higher than that of animals with pathologies in their wombs.

de Arujo et al. (2017) studied the mineral requirements of gelded kids raised under pasture conditions in the semi-arid regions of Brazil. In the meat samples taken during the control slaughtering from the carcasses of the gelded kids with a live weight of 15.37±0.30kg, the amount of zinc fluctuated between 23.68-27.81mg/kg, an iron concentration between 35.70-47.29mg/kg, the amount of manganese between 0.86-1.09mg/kg, a copper concentration between 1.45-1.75mg/kg and the amount of cobalt between 0.83-0.87mg/kg. The results obtained in these studies are in agreement with our experimental materials. In particular, the results obtained for iron, copper, manganese, and zinc agree quite well with our results for kids.

Thus, the analysis of experimental materials obtained on the biceps femoris muscle shows that, statistically, the amount of nitrogen and calcium in kid meat is higher than that of lamb meat. The amount of iron, copper, and zinc in the samples taken from lamb meat is higher than the indicators of the samples taken from kid meat.

Table 3: Comparative study of the amount of macro- and microelements in the biceps femoris muscle of lambs and kids.

Indicators	Units	In lamb meat	In kid meat
Nitrogen (N)	%	0.16±0.01	0.27±0.03*
Phosphorus(P_2O_5)	mg/kg	8.1±0.2	7.17±0.46
Potassium (K_2O)	mg/kg	2722.3±129.7	2835.3±151.97
Calcium, Ca	mg/kg	232.3±8.87	604.2±11.47**
Magnesium, Mg	mg/kg	135.0±4.67	156.6±3.33
Sodium, Na	mg/kg	558.9±14.7	738.3±21.47
Iron, Fe	mg/kg	6.0±0.47	2.37±0.12*
Copper, Cu	mg/kg	0.22±0.02	0.05±0.01**
Zinc, Zn	mg/kg	15.3±0.87	7.2±0.73*
Manganese, Mn	mg/kg	0.1±0.01	0.18±0.02

Note: *P<0.05; ** P<0.01.

In order to more effectively compare the experimental materials obtained, we also found it necessary to provide diagrams for each assigned element. Below are those diagrams:

Analyzing Fig. 1, it is possible to observe that the amount of nitrogen in the samples taken from all three muscles is higher in the kid meat. Indeed, this indicator on the musculus longissimus of dorsi is not observed with a significant difference in lamb and kid meat. However, the amount of nitrogen in the triceps brachii muscle and biceps femoris muscle is statistically significantly higher in kid meat. As already mentioned above, the fact that the amount of protein in kid meat is higher than that of lamb meat is also reflected in many literature data.

The data on the amount of phosphorus show that (Fig. 2) the amount of phosphorus in all three muscles is high in lamb meat. In particular, the amount of phosphorus in the musculus longissimus of dorsi is statistically significantly higher in lamb than in kid meat. The same trend is observed for the triceps brachii and biceps femoris muscles. As for the amount of potassium, there is no significant difference in lamb and kid meat (Fig. 3). It can only be said that the lambs prevail on the musculus longissimus of dorsi and the kids on the other two muscles.

Analyzing the calcium indicators (Fig. 4), we see that this substance in the musculus longissimus of the dorsi and biceps femoris muscle is statistically reliably higher in the kid meat. Interestingly, the amount of calcium in the triceps brachii muscle is statistically more in lamb meat. Regarding magnesium amount (Fig. 5), kid meat is dominant. Thus, the results obtained for the triceps brachii muscle and biceps femoris muscle show that this element is statistically reliably higher in kid meat. The amount of magnesium in the musculus longissimus of dorsi is almost the same for lambs and kids.

As for the concentration of sodium (Fig. 6), we observe the consistency of the results obtained for magnesium. That is, kid meat predominates on the triceps brachii muscle and biceps femoris muscle. The concentration of this element in the triceps brachii muscle is statistically significantly more in the kid meat. The amount of iron (Fig. 7) is higher in lamb meat for all three muscles. However, statistically, significant differences are recorded only for the biceps femoris muscle.

The analysis of indicators for the amount of copper (Fig. 8), zinc (Fig. 9), and manganese (Fig. 10) showed that the concentration of these microelements is statistically higher in lamb meat.

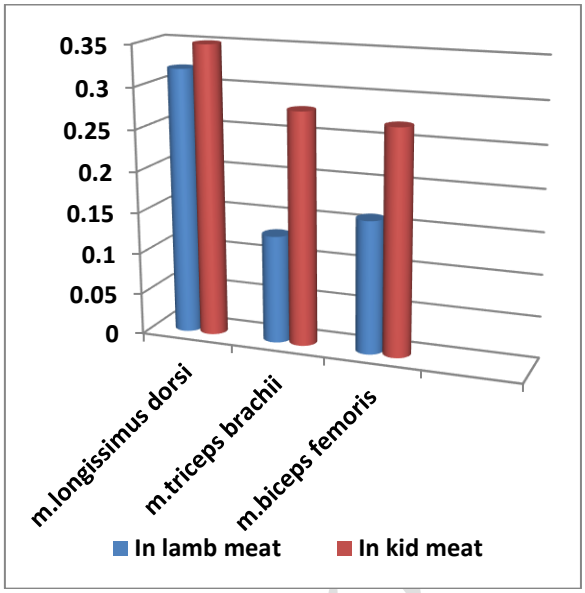

Fig. 1: Amount of nitrogen (%) in meat samples taken from different parts of lamb and kid carcasses.

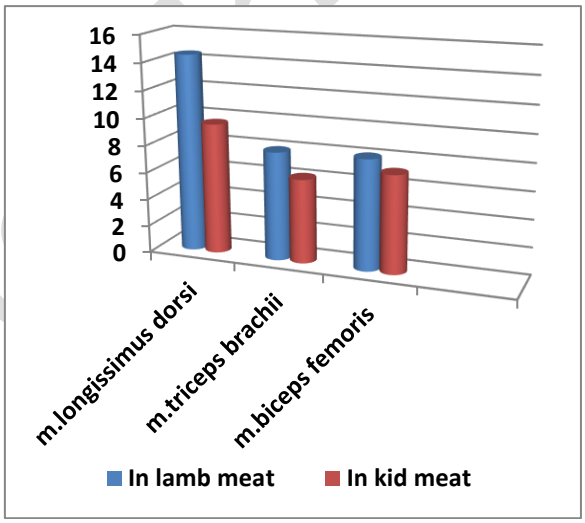

Fig. 2: Amount of phosphorus (g/kg) in meat samples taken from different parts of lamb and kid carcasses.

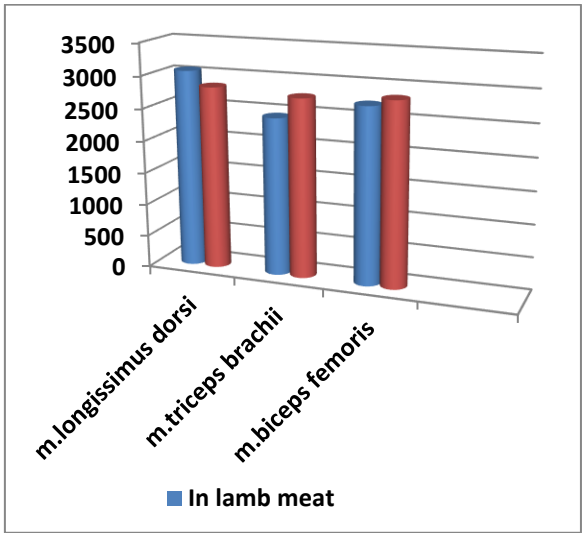

Fig. 3: Amount of potassium (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

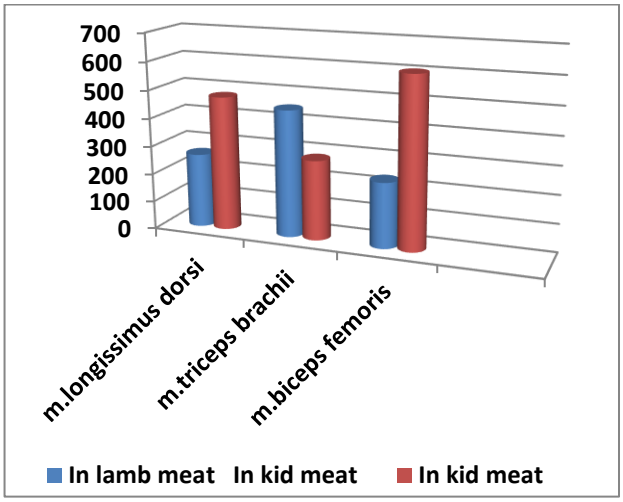

Fig. 4: Calcium amount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

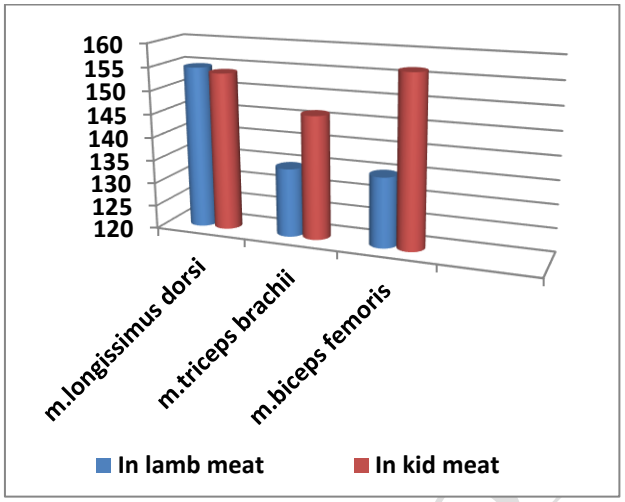

Fig. 5: Magnesium amount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

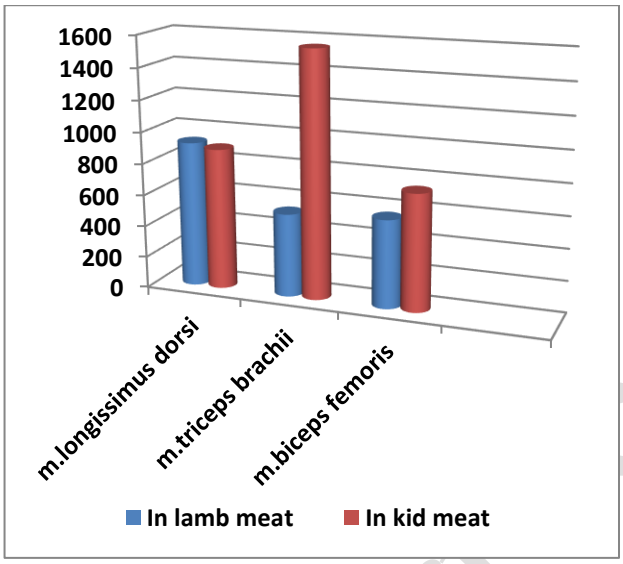

Fig. 6: Sodium amount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

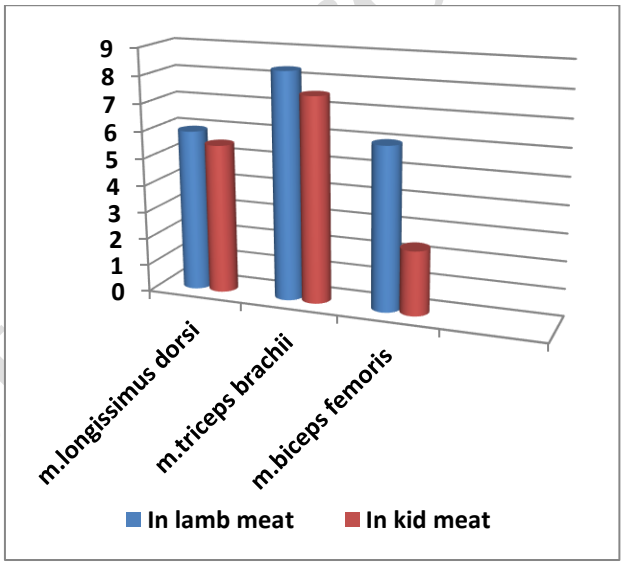

Fig. 7: Ironamount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

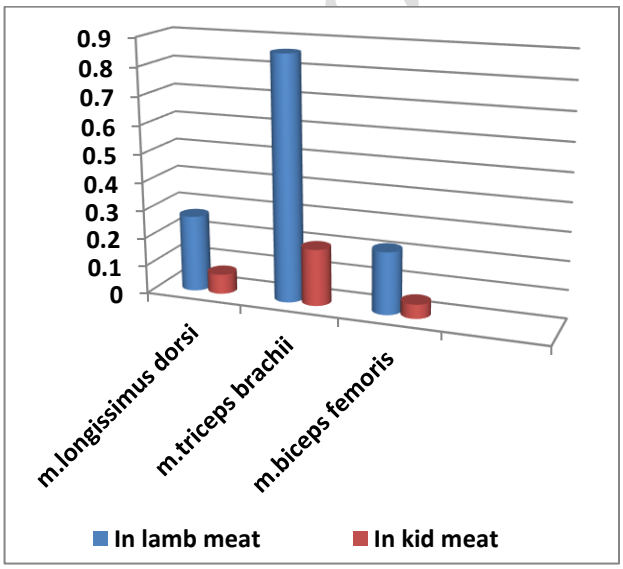

Fig. 8: Copper amount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

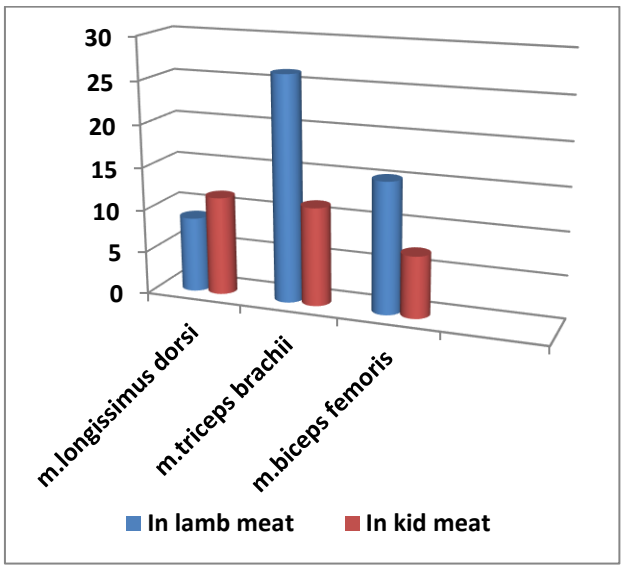

Fig. 9: Zinc amount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

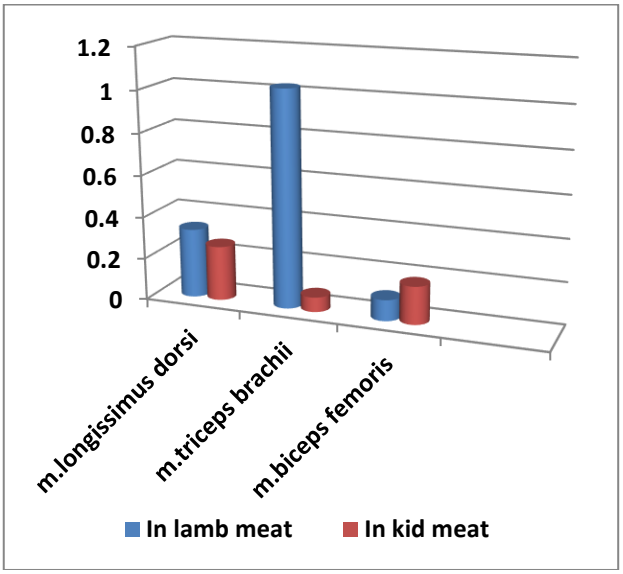

Fig. 10: Manganese amount (mg/kg) in meat samples taken from different parts of lamb and kid carcasses.

Conclusion

Thus, with our studies, we come to the following conclusions:

1. The obtained experimental materials show that on meat samples taken from the musculus longissimus of dorsi, the amount of calcium in kid meat is 80.96% (P<0.01) compared to lamb meat, and the amount of zinc is 31.5% (P<0.05) higher than in goat meat. The amount of phosphorus, potassium, sodium, and copper in lamb meat is 49.9 (P<0.05), 7.98, 3.09, and 85.7% (P<0.01), higher than in kid meat, respectively.
2. The amount of nitrogen in the triceps brachii muscle of kids is 115.4% (P<0.01), and the amount of sodium is about 3 times (P<0.01) higher than the same indicator of lamb meat.
   On the contrary, the amount of calcium in lamb meat is 59.1% (P<0.05), the amount of zinc is more than 2 times (P<0.05), and the concentration of copper is more than 4 times (P<0.01) higher than its indicators of kid meat.
3. The amount of nitrogen in kid meat on biceps femoris muscle is 68.75% (P<0.05), and the amount of calcium is more than 2.5 times (P<0.01) than the indicator of lamb meat. In samples taken from the lamb meat, the amount of iron is more than 2 times (P<0.01), the concentration of copper is 4 times (P<0.01), and the amount of zinc is 2 times (P<0.05) higher than the indicators of the samples taken from the kid meat.

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