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Meat quality characteristics of *Infraspinatus, Triceps brachii, Longissimus thoraces, Biceps femoris, Semitendinosus,* and *Semimembranosus* of bactrian *(Camelus Bactrianus)* camel muscles

Abstract. The objective of this study was to evaluate and compare quality characteristics of Infraspinatus (IS), Triceps brachii (TB), Longissimus thoraces (LT), Biceps femoris (BF), Semitendinosus (ST), and Semimembranosus (SM) muscles from nine Bactrian camel carcasses. Individual muscles were collected to measure color, expressed juice, cooking loss, pH, sarcomere length, shear force value, myofibrillar fragmentation index. The pH for the six muscles was monitored at 1, 2, 4, 8, 12, 24 and 48 hrs postmortem. The TB muscle had a significantly ($P<0.05$) higher pH value than LT, ST and SM muscles. The range of variation in expressed juice between the six muscles was 37.10 cm2/g in LT muscle to 41.27 cm2/g in SM muscle. The LT muscle had significantly lower cooking loss and shear force values than IS, ST, TB, SM and BF muscles. The LT muscle had significantly higher L* values than TB, ST, SM and BF muscles. However, the LT muscle had a significantly lower myofibrillar fragmentation index than the other muscles. This study indicated that meat quality characteristics varied among Bactrian camel muscle types and the knowledge of this variation allows for better marketing and processing of camel meat.
Keywords: Bactrian, camel, muscles, meat quality.

The camel is a unique animal because it has an exceptional ability to survive and thrive under adverse climatic conditions. Therefore, camels offer ideal sources of meat, and milk production in areas where the climate adversely affects other animal's production efficiency. The camel population in Kazakhstan is 168,000 heads with 80% of total camels being Bactrian (*Camelus Bactrianus*).

The demand for camel meat appears to be increasing due to health reasons, as they produce meat with less fat with less levels of cholesterol than other meat animals [1]. Camel meat is also relatively high in polyunsaturated fatty acid in comparison to other ruminants [2, 3, 4, 5]. This is an important factor in reducing the risk of cardiovascular disease, which is related to saturated fat consumption [6]. Camel meat is also used for remedial purposes for diseases such as hyperacidity, hypertension, pneumonia and respiratory disease as well as an aphrodisiac [7].

Traditionally, camel meat comes mostly from old animals that are primarily kept for milk, racing, and transportation, rather than for meat production. This is likely to have contributed to the view among general consumers that camel meat is unacceptably tough. The study of meat quality characteristics of Bactrian camel can provide more balanced information which can be used to improve the marketing of camel meat. However, based on our knowledge, there is currently no information on the quality characteristics of Bactrian camel meat.

An efficient marketing system for camel meat requires more information on meat quality characteristics of various muscles from different regions for quality classification purposes. The identification of camel muscles that can be marketed might increase the demand for camel products by improving the consistency of products and allowing processing technologies to be targeted toward maximizing camel carcass value. Moreover, marketing camel muscles in this way allows the production of more attractive cuts with greater quality characteristics.

The objective of this study was to determine the quality characteristics of *Infraspinatus* (IS), *Triceps brachii* (TB), *Longissimus thoraces* (LT), *Biceps*

femoris (TF), *Semitendinosus* (ST), and *Semimembranosus* (SM) of Bactrian camel muscles. This may identify more appropriate uses and applications for specific muscles. In addition specific market needs may be identified.

Materials and Methods

2.1 *Animals and Meat Samples.* Nine Bactrian camels (2 to3 years of age) were slaughtered at Zhengis Sharua Kozhalygy camel farm, Kyzylorda, Kazakhstan. *The Infraspinatus* (IS), *Triceps brachii* (TB), *Longissimus thoraces* (LT), *Biceps femoris* (BF), *Semitendinosus* (ST), and *Semimembranosus* (SM) muscle samples were removed from their origin and insertion within 20 min postmortem. Each individual muscle was trimmed off external fat and transported in an insulated cool box and kept in a chiller (3-4oC) for 48 hrs.

2.2 *Muscle pH Decline.* The pH from the left side of IS, TB, LT, BF, ST and SM muscles was monitored using a portable pH meter (Hanna waterproof pH meter, Model Hi 9025) fitted with a plastic body open junction, conic (Hanna FC200B) and a temperature adjusting probe. Measurements, designated as pH (1, 2, 4, 8, 12 and 24 hrs postmortem) were recorded. For each measurement, the pH probe and the thermometer were inserted into muscles to a similar depth (2 cm).

2.3 *Meat Quality Evaluation.* Meat quality measurements were carried out on each individual muscle at 48 h postmortem. The ultimate pH was assessed in homogenates at 20-22oC (using an Ultra Turrax T25 homogeniser) of duplicate 1.5-2 g of muscle tissue in 10 ml of neutralized 5-mM sodium iodoacetate and the pH of the slurry measured using a Metrohm pH meter (Model No. 744) with a glass electrode. Chilled muscle samples (13 mm x 13 mm cross section) for assessment of shear force by a digital Dillon Warner-Bratzler shear device were cooked in a water bath at 70oC for 90 min. Sarcomere length by laser diffraction was determined using the procedure described by Cross et al. (1980/1981). Myofibrillar fragmentation index was measured using a modification of the method of Johnson et al. This basically measured the proportion of muscle fragments that passed through a 231-μm screen after the sample had been subjected to a standard homogenization treatment. A 5g (±0.5 g) sample of diced muscle (6 mm3 pieces) was added to 50 ml of cold physiological saline (85% NaCl), plus 5 drops of antifoam A emulsion (Sigma Chemical), in a 50 ml graduated cylinder, and homogenized at ¼ speed using an 18 mm diameter shaft on an Ultra-Turrax homogenizer for 30-second periods separated by a 30 second rest period. The homogenate was poured into a pre-weighed filter (231 x 231 μm holes). The filter typically ceased dripping after 2-3 hrs, at which time the samples were dried at 26-28oC in an incubator for 40 hrs before being re-weighed. The myofibrillar fragmentation index values presented herein were calculated as 100 minus the percentage of the initial meat sample weight that remained on the filter. Expressed juice, a method of measuring water holding capacity, was assessed by a filter paper method, as the total wetted area less the meat area (cm2) relative to the weight of the sample (g). Approximately 60 min after exposing the fresh surface, CIE L*, a*, b* light reflectance coordinates of the muscle surface, as an objective color were measured at room temperature (20±2oC) using a Minolta Chroma Meter CR-300 (Minolta Co., Ltd., Japan).

2.4 Statistical Analysis. The general liner model, ANOVA procedure within SAS (1993) was used to compare the effect of location of different muscles on quality characteristics of Bactrian camel Infraspinatus (IS), Triceps brachii (TB), Longissimus thoraces (LT), Biceps femoris (BF), Semitendinosus (ST), and Semimembranosus (SM) muscles. Significant differences between means were assessed using the least-significant-difference procedure.

Results and Discussion 2.1 Kinetics of Decline pH. Change pH-time curves for the IS, TB, LT, BF, ST and SM muscles during postmortem period are presented (Figure 1).

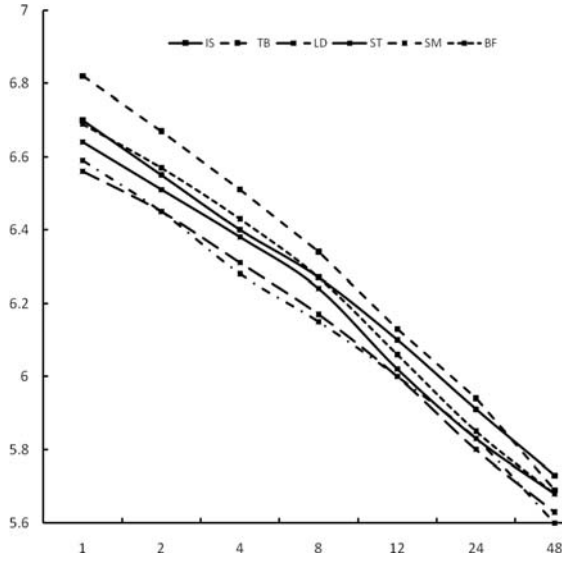

Figure 1 – Mean changes in pH within the Infraspinatus (IS), Triceps brachii (TB), Longissimus thoraces (LT), Biceps femoris (BF), Semitendinosus (ST), and Semimembranosus (SM) muscles from bactrian camel carcasses

The most readily measurable indicator of the conversion of glycogen into lactic acid was the drop in pH value. Lactate accumulation and the release of protons from adenosine triphosphpate hydrolysis in postmortem muscle a pH decline [8]. According to Lindahl et al. [9], the early post-mortem pH development plays an important role in determining the rate and extent of muscle tenderization and the colour characteristic of meat. In the present study, changes in glycolysis between different muscles were monitored by measuring the rate of pH fall after slaughter. TB muscle had significantly ($P<0.05$) higher pH value (6.81) than LT (6.56), ST (6.64) and SM (6.59) muscles. The greatest pH fall occurred in LT and SM at one hr postmortem, while the lowest pH falls occurred in TB muscle. The mean pH values underwent a slow decline until an ultimate pH at 48 hr postmortem. The pH decline of meat is related to the glycogen content of muscle at slaughter, where lower glycogen contents may result in decreased rates of glycolysis; hence, a slower accumulation of lactic acid and a slower rate of post-slaughter pH decline [10]. The time needed for muscle pH values to fall to 6.0, is a reflection of earlier rigor onset. The LT was the only muscle for which the pH fell below 6 at 12 hrs (Fig. 1). One of the important procedures to avoid cold shortening is reducing the time required for the muscle to reach pH 6.0. This determines the period of delay necessary before muscle temperature can be dropped below 10oC if cold shortening is to be avoided [11].

Camels are luconeogenesis animals due to the presence of humps. The amount of enzymes in the camel's glycolytic pathway causes slower glycogen degradation and pH decline in comparison to other livestock [10].

2.2 Meat Quality Characteristics. Meat Quality Characteristics of the Bactrian camel muscles are presented in Table 1. The ultimate pH of muscle is a major determinant of meat quality and is largely determined by the depletion of glycogen and accumulation of lactic acid pre- and post-slaughter [1]. In the present study, The ST and SM had significantly lower ultimate pH values than IS, TB, ST and BF muscles (Table 1). The ultimate average pH value of the Bactrian camel muscles was within the normal range of dromedary camel meat [12, 13, 14, 15, 16, 17, 18]. The ultimate pH value of meat is the result of a combination of many factors including Preslaughter handling, post-mortem treatment and muscle physiology

Table 1 - Meat quality characteristics of six muscles from Bactrian camel

	Muscle[1]						
	IS	TB	LT	ST	SM	BF	SEM[2]
Ultimate pH	5.73^{b}	5.69^{b}	5.63^{a}	5.68^{b}	5.60^{a}	5.68^{b}	0.017
Expressed juice (cm^2/g)	38.21	37.96	37.10	40.37	41.27	38.79	1.754
Cooking loss %	32.7^{b}	32.56^{b}	25.07^{a}	33.99^{b}	33.94^{b}	32.11^{b}	0.847
W-B Shear force (Kg)	10.75^{c}	8.86^{b}	6.04^{a}	9.95^{bc}	9.83^{bc}	8.62^{b}	0.591
Sarcomere (μm)	1.45^{a}	1.54^{a}	1.70^{b}	1.47^{a}	1.53^{a}	1.52^{a}	0.053
Myofibril Fragmentation Index (%)	76.76^{b}	76.94^{b}	73.94^{a}	77.74^{b}	76.78^{b}	78.42^{b}	0.609
Lightness colour (L^*))	32.41^{b}	30.79^{a}	33.40^{c}	30.22^{a}	30.82^{a}	30.09^{a}	0.313
Redness colour (a^*)	13.21	13.14	13.81	12.84	13.78	13.45	0.438
Yellowness colour (b^*)	3.78^{b}	3.40^{a}	3.96^{b}	3.16^{a}	3.54^{ab}	3.56^{ab}	0.176

[1]Muscle: IS; *infraspinatus*, TB: *triceps brachii*, LT; *longissimus thoracis*, ST; *semitendinosus,* SM; semimembranosus, BF; biceps *femoris*. [2]SEM: standard error for the mean.

The low muscle glycogen stores at slaughter do not allow the development of a desirable pH of the lean tissue after slaughter [21]. The trend of high ultimate pH of the samples from younger camels in the present study might be due to differences in proportions of muscle fiber types and/or lower muscle glycogen stores at the time of slaughter. Fiber types have been shown to differentiate at various stage of development and therefore have different metabolic functions in the body [21]. Such differences might cause different patterns of muscle metabolism [22], and ultimate muscle pH. The difference in ultimate pH between the six muscles in the present study might be due to the difference in initial muscle glycogen content. The difference in ultimate pH between the current study and other study values may be due to a combination of several factors including breed, preslaughter handling, season, postmortem treatment and metabolism of the muscles.

Expressed juice is the ability of meat to retain its constituent water when an extraneous force or treatment is applied to it. This property affects the reten-

tion of vitamins, minerals and salts, as well as the volume of water retained. Muscles that lose water easily are drier and lose more weight during refrigeration, storage, transport and marketing [23]. The expressed juice of meat products is a very important quality attribute which has an influence on product yield, which in turn has economic implications, but is also important in terms of eating quality. The variation in expressed juice between muscles in the current study ranged from 37.10 (LT) to 41.27 (SM) cm2/g. The difference can be explained by the location of muscle, difference muscle activity, proportion of muscle fiber types, pH, intramuscular fat and the ratio of water to protein. The expressed juice in the Bactrian camel is within the range of dromedary camel muscles [15, 24]. However, LT muscle had significantly ($P<0.05$) lower cooking loss% (25.07%) than IS (31.6%), TB (29.2%), ST (28.5%), SM (30.6%), and BF (29.5%). The cooking loss% of Bactrian camel muscles contained were lower than those reported in dromedary camel muscles. The difference might be due to composition of muscle between the two breeds.

Tenderness is the most important organoleptic characteristic and the predominant quality determinant of red meat [25]. The sensory assessment of tenderness is usually supported by Warner-Bratzler shear force data [26]. The most marked difference in meat quality characteristics between camel meat and that of other livestock is believed to be tenderness [4]. Mean of Warner-Bratzler Shear force values (kg) for six muscles are given in Table 1. The LT muscle had significantly ($P<0.05$) lower shear force value (6.04) than IS, TB, ST, SM or SM muscles. The IS muscle had a significantly ($P<0.05$) higher value (10.75 kg) than TB (9.95 kg) and BF (9.83 kg). The LT muscle's shear force value was similar to those reported by Kadim et al, (2006, 2009a, b). Meat tenderness is affected by changes in myofibrillar proteins and the amount and structure of connective tissue [27]. Moreover, postmortem proteolysis, intramuscular fat, intramuscular connective tissue and the contractile state of the muscle are the most important characteristics to be considered [28]. These factors also contribute to the difference in tenderness between different muscles within camel carcasses. Therefore, variation between muscles in Bactrian camels might be due to the connective tissue structure and its heat stability. Measurement of myofibril fragmentation is one of the most widely used methods to determine postmortem proteolysis in meat [29]. In the present study, the low myofibrillar fragmentation index in LT (73.94) muscle compared to other muscles, partially explain the variation in tenderness. In the present study, the myofibrillar fragmentation index value of the LT muscle was similar to those values in dromedary camels reported by Kadim et al. [1]. However, the myofibrillar fragmentation index values in the present study were higher than those reported by Suliman et al. [17]. The difference between this study and previous studies may be due to breed, age, and ant- and postmortem factors.

Meat colour is one of the most important criteria in initial selection by the consumer. It is related to the concentration of myoglobin and its chemical state on the surface of the meat, the structure and physical state of muscle proteins and the proportion of intramuscular fat [23]. In the present study, the LT and IS muscle had significantly ($P<0.05$) higher lightness (L*) values (33.40) and IS (32.41), than TB (30.79), ST (30.22), SM (30.82) and BF (30.09) muscles. Moreover, the variation between IS and LT is significant. This study indicated that LT is the lightest muscle and SM the darkest muscle in Bactrian camel. The range of redness (a*) and yellowness (b*) values were from 12.84 to13.78 and 3.16 to 3.96, respectively. The lightness (L*) and redness (a*) values in the present study were similar, while the yellowness (b*) values were lower than those values in dromedary camel reported by Kadim et al. (2006, 2009a,b) and Abdelhadi et al. [18].

Conclusion

Results of quality characteristics indicate that several muscles were consistently superior in tenderness and over all palatability. The muscles of the longissimus thoracis were ranked high while the semimembranosus and biceps femoris muscles were ranked low. This data indicates that some muscles would have a potentially greater economic value if they were separated and used independently. Quality parameters of individual muscles can be used to improve marketing of camel meat, and would provide more information about meat quality characteristics of Bactrian camel meat.

Refferenses

1 Kadim I. T., Mahgoub O. and Purchas R.W. A review of the growth, and of the carcass and meat quality characteristics of the one-humped camel (Camelus dromedaries) // Meat Science. – 2008. – V.80. – P. 555-569.

2 Dawood A., Alkanhal M.A. Nutrient compo-

sition of Najdi-Camel Meat // Meat Science. – 1998. – V. 39. – P. 71-78.

3 Knoess K. The camel as a meat and milk animal // World Animal review. – 1977. – V. 22. – P. 3-8.

4 Mukasa-Mugerwa E. The camel (Camel dromedaries): A biographical review. – Addis Ababa, Ethiopia: International Livestock Centre for Africa. – 1997. – P. 144.

5 Rawdah T.N., El-Faer M.Z. and Koreish S.A. Fatty acid composition of the meat and fat of the one-humped camel (Camelus dromedaries) // Meat Science. – 1994. – V. 37. – P. 149-155.

6 Giese J. Developing low fat meat products // Food Technology. – 1994. – V. 46. – P. 100-108.

7 Kurtu M.Y. An assessment of the productivity for meat and carcass yield of camel (Camelus dromedarious) and the consumption of camel meat in the Eastern region of Ethiopia // Tropical Animal Health and Production. – 2004. – V. 36. – P. 65-76.

8 Bendall J.R. Post-mortem changes in muscle / In: Bournr G.H. The structure and function of muscle. – New York: Academic Press, 1973. – 2nd ed. – P. 243-309.

9 Lindahl G., Henckel P., Karlsson A. H., Andersen H. J. Significance of early postmortem temperature and pH decline on colour characteristics of pork loin from different rossbreeds // Meat Science. – 2006. – V. 72(4). – P. 613–623.

10 Immonen K., Puolanne E. Variation of residual glycogen glucose concentration at ultimate pH values below 5.75 // Meat Science. – 2000. – V. 55(3). – P. 279–283.

11 Chrystall B.B., Devine C.E., Davey C.L. Studies in electrical stimulation: post-mortem decline in neverous response in lambs // Meat Science. – 1983. – V. 4. – P. 69-78.

12 Al-sheddy I., Al-Dagal M., Bazaraa W.A. Microbial sensory quality of fresh camel meat treated with organic acid slats and /or bifidobacteria // Journal of Food Science. – 1999. – V. 64. – P. 336-339.

13 Cristofaneli S., Antonini M., Torres D., Polidori P. and Renieri C. Meat and carcass quality from Peruvian Ilama (Lama glama) and alpaca (Lama Pacos) // Meat Science. – 2004. – V. 66. – P. 589-593.

14 Kadim I. T., Mahgoub O., Al-Marzooqi W., Al-Zadgali S., Annamali K., Mansour M. H. Effects of age on composition and quality of muscle Longissimus thoracis of the Omani Arabian camel (Camelus dromedaries) // Meat Science. – 2006. – V. 73. – P. 619-625.

15 Kadim I.T., Mahgoub O., Al-Marzooqi W. Meat quality and composition of Longissimus thoracis from Arabian camel (Camelus dromedaries) and Omani beef: A Comparative Study // Journal of Camelid Science. – 2008. – V. 1. – P. 38-48.

16 Shariatmadari R., Kadivar M. Postmortem aging and freezing of camel meat (a comparative study) // 52nd International Congress of Meat Science and Technology. – Dublin, 2006. – P. 673-674.

17 Suliman G., Sami A., Lowaimer A. and Koohmaraie M. Effect of breed on the quality attributes of camel meat // Indian Journal of Animal Sciences. – 2006. – V. 81. – P. 407-411.

18 Abdelhadi O.M.A., Babiker S.A., Picard B., Jurie C., Jailler R., Hocquette J.F., Faye B. Effect of season on contractile and metabolic properties of desert camel muscle (Camelus xsanguinat) // Meat Science. – 2012. – V. 90. – P. 139-144.

19 Marsh B.B. The basis of tenderness in muscle foods // Journal of Food Science. – 1977. – V. 42. – P. 295-297.

20 Thompson J. Managing meat tenderness // Meat Science. – 2002. – V. 62. – P. 295-308.

21 Ashmore C.R., Tompkins G., Doerr L. Postnatal development of muscle fibre types in domestic animals // Journal of Animal Science. – 1972. – V. 34. – P. 37-41.

22 Swatland H. J. The challenges of improving meat quality // Canadian Journal of Animal Science. - 1982. – V. 62. – P. 15-24.

23 Beriain M.J., Bass P., Purroy A., Treacher T. Effect of animal and nutritional factors and nutrition on lamb meat quality // CIHEAM. – 2000. – P. 75-86.

24 Kadim I.T., Mahgoub O., Al-Marzooqi W., Khalaf S.K., Mansour M.H, Al-Sinawi S.S.H., Al-Amri I.S. Effect of electrical stimulation on histochemical muscle fiber staining, quality and composition of camel and cattle longissimus thoracis muscles. Journal of Food Science. – 2009. – V. 74. – P.44-52.

25 Koohmaraie M. The role of endogenous proteases in meat tenderness // Proceedings of Reciprocal Meat Conference. – 1988. – V. 41. – P. 89.

26 Wheeler T.L., Koohmaraie M. Measurement of Warner-Bratzler shear force in Science and Technology Receprocation Fair // 47th Annual Reciprocal Meat Conference Proceedings, National Livestock and Meat Board, Chicago, 1994. – P. 49-50.

27 Chen Q.H., He G.Q., Jiao Y.C., Ni H. Effects of Elastase from a Bacillus Strain on the Tenderization of Beef Meat. Food Chemistry. – 2006. – V. 98. – P. 624-629.

28 Kemp C.M., Sensky P.L., Bardsley R.G., But-

tery P.J., Parr T. Tenderness: an Enzymatic View // Meat Science. – 2009. – V. 84. – P. 248-256.

29 Olson D. G., Parrish F. C., Stromer M. H. Myofibril fragmentation and shear resistance of three bovine muscles during postmortem storage // Journal of Food Science. – 1976. – V. 41. – P. 1036–1041.

Г. Райымбек, Б. Файе, Г. Конуспаева, И.Т. Кадим

Бакриандардың *Infraspnatus* (IS), *Triceps brachii* (TB), *Longissimus thoraces* (LT), *Biceps femoris* (BF), *Semitendinosus* (ST) және *Semimembranosus* (SM) бұлшық еттерінің сапалық мінездемелері

Бұл зерттеу жұмысының мақсаты – тоғыз бактриан түйесінен алынған Infraspnatus (IS), Triceps brachii (TB), Longissimus thoraces (LT), Biceps femoris (BF), Semitendinosus (ST) және Semimembranosus (SM) бұлшық еттерінің сапалық қасиеттерін бағалау және салыстыру. Бұлшық еттің сапалық қасиетін анықтайтын параметрлер ретінде еттің түсі, бөлетін шырыны, піскенде жоғалтатын салмағы, pH, саркомер ұзындығы, еттің жұмсақтығы және миофибрилярлық фрагментациялық индексі өлшенді. Зерттеу жұмысы еттің сапалық қасиеттерінің ұқсамаған бұлшық еттер арасында әртүрлі болатындығын көрсетті және бұл көрсеткіштер болашақта түйе етінен әртүрлі ет өнімдерін алуда, сондай-ақ түйе еті маркетингіне жол ашуда алатын маңызы зор.

Түйін сөздер: бактриан, түйе, бұлшық еттер, ет сапасы.

Г. Райымбек, Б. Файе, Г. Конуспаева, И.Т. Кадим

Качественные характеристики *Infraspnatus* (IS), *Triceps brachii* (TB), *Longissimus thoraces* (LT), *Biceps femoris* (BF), *Semitendinosus* (ST)) и *Semimembranosus* (SM) мышц бактрианов

Целью данного исследования было оценить и сравнить качественные характеристики Infraspnatus (IS), Triceps brachii (TB), Longissimus thoraces (LT), Biceps femoris (BF), Semitendinosus (ST)) и Semimembranosus (SM) мышц девяти туш бактрианов. Индивидуальные мышцы были собраны для измерения цвета, выжатого сока, потерь приготовления, pH, длины саркомера, мягкости, индекса миофибриллярных фрагментаций. Это исследование показало, что характеристики качества мяса варьировались в зависимости от типов мышц верблюдов-бактрианов и знание этих изменений позволяет лучше продавать и перерабатывать верблюжье мясо.

Ключевые слова: акриан, верблюд, мышцы, качество мяса.