International Journal of Social Science and Humanities Research-MIYR
Volume 3, Issue 3, pp.1~12, 2023
ISSN(print): 2788-9092, ISSN(Online): 2788-9106
https://doi.org/10.53468/mifyr.2023.03.03.1

Results of studying the fatty acid composition of yak meat of Mongolia

Tserenkhand Zorigtbaatar[1*], Tumurtogtokh Erdenetsogt[2], Damdinsuren Dorjoo[3], Erkigul Bukyei[4], Enkhjargal Buyandelger[5]

[1,2,3,5] Professor, Department of Commodity study, monitoring and inspection, SASB, Mongolian University of Life Sciences, Mongolia
[4] Professor, Department of Food and Agriculture, SET, Mongolian University of Life Sciences, Mongolia

[1]Tserenkhand.z@muls.edu.mn*, [5]Enkhjargal.b@muls.edu.mn

Abstract— The objective of this paper was to compare the general chemical parameters and fatty acid composition of yak meat of 2 different ages bred in 2 different regions. The survey was conducted from November 2022 to June 2023. Yak meat is rich in myoglobin, which easily oxidizes with oxygen in the air, giving the meat a brownish-red color. Yak fat has a bright yellow color due to the high amount of carotene that produces vitamin A. In our study, we determined the general chemical parameters and fatty acid composition by preparing meat samples from yaks bred in Duut soum of Hovd province and Bulgan soum of Arkhangai province. According to the results of the research, which the contents of moisture of yak meat was 68.06%, fat was 4.94%, protein was 22.5%, calories were 147.5 kcal, and mineral was 1.15%.

In determining the composition of fatty acids, the unsaturated fatty acids of the Duut yak meat in the high mountain region were 60.69%, and the saturated fatty acids were 38.8%, also the unsaturated fatty acids of the Bulgan yak meat in the forest region were 48.89%, and the saturated fatty acids were 50.99%.

Also, among the saturated fatty acids in yak meat, palmitic acid 19.88%-23.89%, stearic acid 11.83%-14.17%, and oleic acid 35.4%-40.67% were the most abundant among unsaturated fatty acids. The samples yielded similar results in general chemistry, but differed in fatty acid composition. It is believed that it depends on the characteristics of the locality and natural area where the samples were prepared.

Keywords— Fatty acid, Calories, Protein, Fat, Yak Meat

Received: 2023.06.05
Reviewed: 2023.06.09
Accepted: 2023.08.27
* Corresponding Author: Tserenkhand Zorigtbaatar

1. INTRODUCTION

Yak have been bred in the mountainous areas of the Himalayas, Tenger mountain, Altai Khangai and Khuvsgol since ancient times. There are above 1 million yaks are distributed in 13 provinces and 132 soums in the mountainous and forest regions of in Mongolia. More than 50% of yaks are located above 2000 meters above sea level, and about 40% are located at an altitude of 1600-2000 meters. They use water in local pastures that are not suitable for grazing other types of animals, and they produce products under normal conditions of maintenance, so they are economically efficient animals [1], [2].

Yak meat is rich in myoglobin, which easily oxidizes with oxygen in the air, giving the meat a brownish-red color. Yak fat has a bright yellow color due to the high amount of carotene that produces vitamin A. Also, the meat is relatively coarser, darker, and has less fat, but all this does not reduce the quality, but shows that it has an appropriate fat-protein ratio and is rich in proteins and vitamins. Yak meat is similar to beef in terms of food demand and value in foreign markets [1].

One of the important components of food is fat, which accounts for 30-40% of energy requirements. Fat is not synthesized in human body tissues, so it needs to be obtained from food. It also plays an important role in forming the physical and chemical properties of food. Fats are a group of water-insoluble organic compounds that can be extracted from tissues with non-polar solvents such as chloroform, ether, and benzol. It also plays two main roles: on the one hand, it becomes a component of the membrane structure, and on the other hand, it becomes a form of stored energy in metabolism [2], [3], [4]. Being a component of the cell membrane, fat plays an important role in membrane substance penetration, nerve tissue transmission, and cell-to-cell interaction[4].

Fat is an important source of essential fatty acids since it facilitates the absorption of fat-soluble micronutrients such as vitamins and trace elements. In addition, fat is an important attribute for determining the consumers' acceptance of food products, that is, of their desirable appearance, flavor, aroma, texture, and mouth feel [2], [5]. Fat tissue is the second most important anatomical and morphological component of eviscerated animals. Animal fat is a natural product with a low level of non-nutritional substances. Moreover, animal fats are mostly saturated, stable at elevated temperatures, and can be stored longer compared to plant-based fats. Reduced oxidation in animal fats ensures less susceptibility to toxins and carcinogens [6], [20]. Yaks are adapted to extreme living conditions and high altitude (2,000 to 5,000 m above sea level). Living in the severe climatic conditions of high mountains, yaks survive by grazing on highland pastures with widely dispersed feed, mostly composed of grass and herbs. The results of the previous research [7] reported that the main fatty acids in yak body and kidney fat were palmitic acid (C16:0), stearic acid (C18:0), and oleic acid (C18:1). The contents of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in yak body fat were 42.7 and 7.95 %, respectively [8].

Fatty acids are considered to be aliphatic carbon acids, exist freely in human organism, and formulate lipids by being linked with each other. Concerning nutrition, the multilinked unsaturated acids or oil acids containing two or more double links, such as linonelic, arahidon acids are more biologically active. These indispensible fatty acids act as organism

cellular cover structure as well as create a source of hormone like substance, prostaglandin [6], [7]. Muscle fat consists of fat cells located between and in muscle threads, and mainly contains triacylglycerol. Solidity of fatty cells depends on variable melting points of fatty acid melting. For instance acids containing 18 carbon atoms, especially stearinic acid /18:0/ melts at 69.6 degree, oleic acid /18:1/- at 13.4 degrees, linoleic acid -/18:2/ at 5 degrees, linolenic acid /18:3/ at 11 degrees respectively [5], [9].

Fatty acids are aliphatic - carboxylic acids, which exist freely in the body and connect with together to consist lipids. From the point of view of nutrients, polyunsaturated fatty acids, or fatty acids containing two or more secondary bonds, such as linoleic, linolenic, and arachidonic acids, are highly biologically active. These irreplaceable essential fatty acids are the structure of the body's cell membranes as well as the source of prostaglandins, a hormone-like substance [3], [3].

Research has shown that fatty acids are involved in the formation of the taste and smell of meat, volatile and aromatic substances are released from the oxidation of lipids during heat treatment and interact with the products of the Mayard reaction to form volatile compounds of aroma and taste, phospholipid unsaturated acids are important in the formation of aroma, fatty tissue is the source of the unique smell of meat [10].

Oleic acid is the main monounsaturated fatty acid found in olive fatty acids. Oleic acid prevents atherosclerosis, increases insulin release, reduces glucose release from the body, improves the immune system, and protects against some types of cancer [11], [12].

The aim of this study was to analyze the fatty acid composition of Mongolian yak meat. First, determined of the general chemical composition of yak meat. Secondly, fatty acid profile of yak meat was measured using gas chromatography (GC). Finally, compared the fatty acid composition of yak meat by region.

2. THEORETICAL BACKGROUND

2.1. RESEARCH MATERIALS AND METHODS

Material: In our research, we determined the general chemical parameters and fatty acid composition by preparing samples of yak meat bred in Duut soum of Hovd province in the highland region and Bulgan soum of Arkhangai province in the forest steppe region according to the standards. Meat moisture was determined by MNS 6477:2014, fatness by MNS 5035:2020, protein by MNS ISO 937:1984, mineral by MNS ISO 936:2003, and calories by SAZ 08:2009.

Methodology for determining fatty acid composition according to SAZ 18:2016: Gas chromatographic method for determination of fatty acid composition according to SAZ 18:2016, samples were prepared according to SAZ 18:2016, and 37 essential fatty acids mainly found in food was determined by HP-FFAP column (30m, I.D-0.32mm F.D., 0.25mm) gas chromatographic instrument with FID detector of Shimadzu factory "FAME 37 (C4-C24) mixture" standard solution was used to determine the composition of fatty acids [9]. Meat samples were collected from animals of the autumn slaughtering season in 2022 (female animals, 4-5, 7-8 years old, of medium nutritional state). Yak of Duut soum in Hovd province were in the highland region at an average altitude of 3, 000 m above sea level. Yak

of Bulgan soum in Arkhangai province were in the forest steppe region at an average altitude of 2,000 m above sea level.

Preparation of samples was done in accordance with the general guidelines on sampling CAC/GL 50-2004 (Codex Alimentarius, 2007) and MNS 2552-89 [13]. Primary fat samples of 200 g each were taken from three different parts of each animal visceral fat. A composite sample was obtained by mixing the primary samples. Each analysis was done at least in three times in order to avoid inaccuracy. To do so, 100 mg of each melted fat sample was transferred into a test tube; 100 µL of 2 M KOH in methanol was added to each sample and the content of tubes was vortexed for 2 -3 minutes. Upon cooling, 5 mL of hexane was added to the sample and the content of the test tube was thoroughly mixed; afterward, it was centrifuged. The clear supernatant was removed from the test tube and injected to a gas chromatography, which was equipped with flame ionization detector and HP-FFAP column (30m, I.D-0.32mm F.D., 0.25mm). Nitrogen was used as a carrier gas with a flow rate of 6.4941 mL/min. The temperature of the detector was at 275 °C. An initial column temperature of 80°C was held for 3 min, then increased at 7°C/min to a final temperature of 240 °C, where it was held for 10 min. Identification of peaks was based on the comparison of their retention times with those of the standard fatty acids. Fatty acids were identified by comparison of retention times to those of a standard mixture. The fatty acid contents were calculated based on a percentage of the peak area [14], [15], [19].

3. ANALYSIS OF RESEARCH

3.1. Results of determined general chemical parameters:

The general chemical parameters of the samples prepared from the two provinces were similar, on average, the content of moisture of yak meat was 68.06%, fat was 4.94%, protein was 22.5%, calories were 147.5 kcal, and mineral was 1.15%.

Table 1. General chemical parameters of yak meat

№	Chemical parameters	Yak meat of Duut soum of Khovd province	Yak meat of Bulgan soum of Arkhangai province	Average
1	Moisture , %	71.02±1.16	65.1±0.08	68.06
2	Fat, %	4.57±0.87	5.32±0.03	4.94
3	Protein, %	22.16±1.84	22.85±1.02	22.5
4	Calories, kcal	129.8±0.4	164.3±0.09	147.5
5	Mineral, %	1.32±0.04	0.98±0.06	1.15

Chemical parameters of meat vary depending on many factors such as location, age, gender, and fatness. As for the 2 sums selected and prepared by us, Duut soum of Hovd province belongs to the high mountain area, and Bulgan soum of Arkhangai province belongs to the forest area. In terms of age, Duut's yak was young, 4-5 years old, and Bulgan's yak was 7-8 years old. According to the results of the research, the fat content of the yak

meat sample taken from Bulgan soum is slightly higher, which is consistent with the pattern of increase in meat yield and fat content as the animal matures.

3.2. Results of determined fatty acid composition

A total of 27 types of fatty acids were identified in yak meat, and the fatty acids accounted for 99.49% and 99.88% of the total fat in the meat of Duut soum yak and Bulgan soum. Determination of fatty acid content in yak meat revealed 12 saturated fatty acids (Table 2). Caprylic, undecane, tridecane and behenic acids were not detected in all samples.

Table 2. Content of saturated fatty acids in yak meat, %

Formula	Fatty acid	Yak meat of Duut soum of Khovd province	Yak meat of Bulgan soum of Arkhangai province	Average
C^{4}:0	Masl	2.09±0.63	4.66±0.08	3.37
C^{6}:0	Capron	-	0.07±0.1	0.07
C^{8}:0	Caprile	-	-	-
C^{10}:0	Caprin	0.09±0.06	0.18±0.05	0.13
C^{11}:0	Andecan	-	-	-
C^{12}:0	Laurin	0.06±0.04	0.1±0.07	0.08
C^{13}:0	Tridecan	-	-	-
C^{14}:0	Myristin	1.15±0.02	2.76±0.09	1.95
C^{15}:0	Pentadecane	0.45±0.16	0.38±0.12	0.41
C^{16}:0	Palmitin	19.88±0.06	23.89±0.62	21.88
C^{17}:0	Heptadecane	0.87±0.1	0.79±0.07	0.83
C^{18}:0	Sterol	11.83±0.14	14.17±0.08	13
C^{20}:0	Arachidin	0.13±0.01	0.08±0.04	0.1
C^{21}:0	Geneikozon	0.12±0.03	-	0.12
C^{22}:0	Begin	-	-	-
C^{24}:0	Lignocerin	2.17±0.37	0.27±0.07	1.22
	Total	38.84±3.62	47.35±2.39	43.09

Six types of monounsaturated fatty acids were detected in yak meat. Among them, oleic acid was the highest (40.67%) and myristoleic acid was the lowest (0.15%) (Table 3).

Table 3. Content of monounsaturated fatty acids in yak meat, %

Formula	Fatty acid	Yak meat of Duut soum of Khovd province	Yak meat of Bulgan soum of Arkhangai province	Average
C_{18}:2c	Linol	7.14±0.25	1.17±0.31	4.15
C_{18}:2t	Linoleum	-	-	
C_{18}:3 n-6	Gamma linolenic acid	0.17±0.09	0.13±0.07	0.15
C_{18}:3 n-3	Alpha linolenic acid	1.67±0.02	0.72±0.04	1.19
C_{20}:3 n-6	of cis 8, 11, and 14 eicosatriene	0.42±0.08	0.11±0.03	0.26
C_{20}:3 n-3	of cis 11, 14, and 17 eicosatriene	-	0.46±0.01	0.46
C_{20}:4 n-6	Arachidonic acid	5.28±0.36	-	5.28
C_{20}:5 n-3	Cis 5,8,11,14,17 eicosapentaene	1.71±0.25	0.23±0.05	0.97
C_{20}:2	Gadolinium	0.28±0.04	-	0.28
C_{22}:2	Adrenic acid	-	-	
C_{22}:6 n-3	DHA	0.29±0.05	0.56±0.06	0.42
	Total	16.96±1.14	3.38±0.57	10.17

According to the results of the composition of fatty acids, the sum of unsaturated fatty acids in Duut's yak meat is 60.69%, and the sum of saturated fatty acids is 38.8%; The total unsaturated fatty acid content of Bulgan's yak meat was 48.89% and the total saturated fatty acid content was 50.99%, respectively. Also, yak meat contained the highest palmitic acid 19.88%-23.89%, stearic acid 11.83%-14.17%, and oleic acid 35.4%-40.67% of unsaturated fatty acids respectively (Fig 1). 9 polyunsaturated fatty acids were found in yak meat, and highest percent is linoleic acid accounted for 7.14%. Linoleic and adrenic acids were not found in yak meat (Table 4).

Table 4. Content of polyunsaturated acids in yak meat, %

Formula	Fatty acid	Yak meat of Duut soum of Khovd province	Yak meat of Bulgan soum of Arkhangai province	Average
C_{10}:1	Caprolein	-	-	-
C_{12}:1	Laureline	-	-	-
C_{14}:1	Myristolein	0.15±0.12	0.25±0.38	0.2
C_{15}:1	Cis-10-pentadecane	1.79±0.02	0.16±0.08	0.97
C_{16}:1	Palmitolein	4.55±0.09	3.84±0.24	4.19
C_{17}:1	Cis-10-heptadecane	1.69±0.78	-	1.69
C_{18}:1	Olein	35.4±0.05	40.67±0.23	38.03
C_{20}:1	Cis-11-eicosane	-	-	
C_{22}:1	Yerukin	0.43±0.07	1.2±0.16	0.81
C_{24}:1	Nervonite	-	-	-
	Total	44.01±1.13	46.12±1.09	45.06

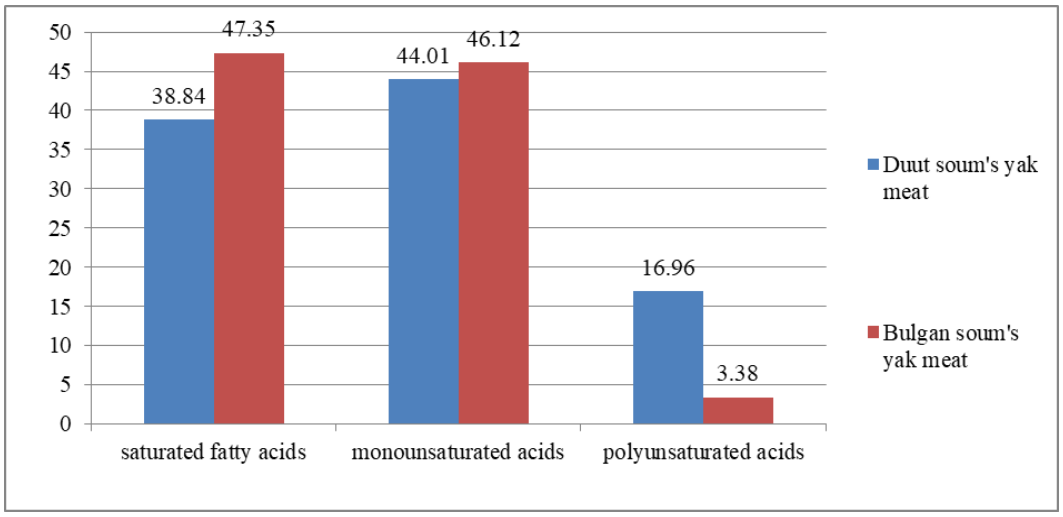

Fig. 1 Total fatty acid content of yak meat comparative figures, %

The total content of polyunsaturated acids in Duut soum yak meat was higher or 13.5%. It is believed that this is due to the high amount of polyunsaturated fatty acids contained in the oils of animals and animals of the high mountain region. The unsaturated fatty acid content of the yak meat from the high mountain region was higher than that of the yak meat bred in the forest region, which confirms the regularity of the increase in the composition of unsaturated fatty acids as the total fat and fatty acid composition of animals and animals rises above sea level.

4. DISCUSSION AND CONCLUSION

4.1. Discussion

In this study, the fatty acid composition of yak meat in two different regions of Mongolia was compared. According to the results, the fat content of yak meat was determined to be slightly higher or 0.6% higher depending on the age. According to J.D. Wood [16] research results, the composition of total fatty acids in animal muscle tissue is similar, and palmitic (C16:0), stearic (C18:0), and oleic acids (C18:1) are dominant, and the amount of these acids depends on the type of animal and tissue, varies in size, and the content of polyunsaturated acids, including linoleic and linolenic acids, is high and relatively abundant in beef.

According to the our results of fatty acid composition, a total of 27 fatty acid components were determined in yak meat, and the above fatty acids accounted for 99.49% and 99.88% of the total fat in Duut soum yak and Bulgan soum meat. Of these, the saturated fatty acid in Duut and Bulgan soum yak meat is 38.84% and 47.35%, monounsaturated fatty acids 44.01% and 46.12%, polyunsaturated fatty acids contained 16.96% and 3.38%, respectively. According to researchers, the amount of C16:0 acid in beef muscle tissue is 26.1%, which is 4-5% more than Mongolian yak meat. However, the content of C18:0 acid was found to be almost the same. 3% polyunsaturated fatty acids were detected in C18:1 yak meat, which indicates the characteristics of Mongolian grassland yak meat [16].

According to Chunyou Liu, Guofeng Jin research results, Additionally, yak hepatic lipids showed the highest content of saturated fatty acids (58.11%) and polyunsaturated fatty acids (PUFA, 25.81%) and the lowest content of monounsaturated fatty acids (MUFA, 16.08%), while yellow cattle AAT had the highest content of MUFA (47.54%) and the lowest content of PUFA (2.36%). The considerable differences between the two in composition suggest that the five tissues of yak are potential sources of bioactive components and essential fatty acids for humans [17].

According to Hou Chengli, Li Xin, Wang Zhenyu research results, Total fatty acid contents of different meat cuts were in the following decreasing order: belly > chuck > tenderloin > rump > sirloin > brisket > shoulder > shank > topside. Oleic acid, palmitic acid and stearic acid were the major fatty acids in yak meat with lesser amounts of docosahexenoic acid, eicosapentaenoic acid and other n-3 fatty acids. Cluster analysis classified these 9 meat cuts into three categories: belly, chuck and other parts based on nutrient, amino acid and fatty acid composition. Overall, we concluded that the contents of protein, fat, amino acid, fatty acid and other nutrients in different parts of yak beef were different. These results can provide a theoretical basis for developing yak meat with high nutritional value and for healthy consumption [18].

4.2. Conclusion

1. The average chemical parameters of yak meat were moisture 68.06%, fat 4.94%, protein 22.5%, calories 147.5 kcal, mineral 1.15%.
2. In determining the composition of fatty acids, a total of 27 types of fatty acids were found in yak meat, 12 saturated fatty acids, 6 monounsaturated fatty acids, and 9 types of polyunsaturated fatty acids were found.
3. The sum of unsaturated fatty acids of Duut soum yak meat was 60.69%, the sum of saturated fatty acids was 38.8%, the sum of unsaturated fatty acids of Bulgan soum yak meat was 48.89%, and the sum of saturated fatty acids was 50.99%, respectively.
4. The high level of unsaturated fatty acids and polyunsaturated fatty acids in Duut Soum yak meat confirms the regularity that the amount of unsaturated fatty acids in animal fat increases as the sea level rises.

4.3. Appreciation

The project "Establishment of Asian food composition database" implemented by the University of Agriculture is being implemented with the funding of the "Asian Food and Agriculture Cooperation Initiative" (AFACI) international organization.

Also, a commissioned work on the topic "Possibilities of introducing traditionally prepared yak meat and dairy products to the market", which is being implemented with the funding of the United Nations Development Program, is being implemented. This research was carried out within the framework of these projects.

I would like to thank the funding organization of the project (Asian Food and Agriculture Cooperation Initiative, UNIDO) and the project team and community.

5. REFERENCES

[1] Enkhtuya.B. (2015) Fatty acid composition of Mongolian livestock. Ulaanbaatar
[2] Batsukh.Ts, Nansalmaa.D, Olziiburen.Ch " Finctional food'' UB 2004
[3] Dumaa. Yo. (2013) Biological Chemistry, Ulaanbaatar
[4] Enkhtuya.B "Biochemical and technological investigation and system property of Mongolian pastoral cattle" UB 2009
[5] Jadambaa.Sh, Alimaa.J, Byambagar.B, Dorj.D ''Chimestry of Food'' UB 2004
[6] Purev.D, Tsevegsuren.N '' Biochimestry'' UB 2006
[7] Tsevegsuren.N, Purev.D (2017) "Guidelines for Biochemistry Practice" Ulaanbaatar
[8] Wang Q., Zhao X., Ren Y., Fan E., Chang H., Wu H., "Effects of high-pressure treatment and temperature on lipid oxidation and fatty acid composition of yak (Poephagus grunniens) body fat", Meat Science, 94, (2013), 489–494
[9] Z.Tserenkhand, E.Tumurtogtokh, (2013) Mongolian Journal of Agricultural Sciences ¹10 (01):89-94
[10] Tsendsuren.S (2014) "Technology of processing raw materials and products of animal origin" Ulaanbaatar
[11] Tserenpuntsag. Sh, Burenjargal. S. (2013) "Veterinary Hospital Sanitation Feasibility Study"
Ulaanbaatar
[12] Ongoodoi. Ch. (2013) "Food Science" Ulaanbaatar
[13] https://www.estandard.gov.mn/
[14] https://www.studocu.com/es-mx/document/universidad-la-salle-mexico/quimica-general/aoac-963-22-ficha-informativa/55094555
https://www.1212.mn/mn
[15] Mongolian Journal of Agricultural Sciences, (2021) Vol 32 No 1, Ulaanbaatar
[16] J.D. Wood, M. Enser, A.V. Fisher, Fat deposition, fatty acid composition and meat quality,
Meat science, (2018) 343–358
[17] Journal of lipid science and technology (2015) Vol.117, 22 January 2015
[18] China meat research center 2019, Vol. 33, No. 2
[19] Gunter Heinz, Peter Hautzinger (2020) "Meat Processing Technology", Ulaanbaatar
[20] J.F. Price, B.S. Schweigert. (2016) The Science of Meat and Meat Products, Germany

AUTHOR'S INTRODUCTION

1. First and Corresponding Author

Tserenkhand Zorigtbaatar tserenkhand.z@muls.edu.mn

Ph.D, Senior lecturer at the Department of Livestock product & monitoring and inspection, School of Animal Science & Biotechnology, Mongolian University of Life Science, Ulaanbaatar, Mongolia
Work field: Food safety, Food inspection and hygiene, Quality control of livestock product

2. Co-Author

Tumurtogtokh Erdenetsogt tumurtogtokh@muls.edu.mn

Ph.D, Associate prof at the Department of Livestock product & monitoring and inspection, School of Animal Science & Biotechnology, Mongolian University of Life Science, Ulaanbaatar, Mongolia

Work field: Food safety, Food inspection and hygiene, Quality control of livestock product

3. Co-Author

Damdinsuren Dorjoo damdinsuren@muls.edu.mn

Senior lecturer at the Department of Livestock product & monitoring and inspection, School of Animal Science & Biotechnology, Mongolian University of Life Science, Ulaanbaatar, Mongolia

Work field: Food legislation, Quarantine control of imported products

4. Co-Author

Erkigul Bukyei erkigul@muls.edu.mn

Ph.D, Senior lecturer at the Department of Agricultural and Food Engineering, University of Life Sciences, Ulaanbaatar, Mongolia

Work field: Food technology, Food safety, Food Nutrition

5. Co-Author

Enkhjargal Buyandelger enkhjargal.b@muls.edu.mn

Ph.D, Associate prof at the Department of Livestock product & monitoring and inspection, School of Animal Science & Biotechnology, Mongolian University of Life Science, Ulaanbaatar, Mongolia

Work field: Food safety, Food Nutrition, Quality control of livestock product, Food chemistry