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Meat Quality and Chemical Composition of Alxa Bactrian Camel

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ABSTRACT

Background: The Alxa bactrian camel, as one of the primary breeds in China, contributes significantly to the local dietary structure as a crucial meat source. However, the existing analysis and research on the quality and chemical composition of Alxa bactrian camel meat lack a comprehensive and systematic approach, leading to a substantial lag in the development and utilization of local camel meat products.

Methods: To investigate the meat quality characteristics of Alxa bactrian camels, 48 individuals were randomly selected from Desert, Gobi, Desert steppe and Mountainous areas based on their ecological environment. Their meat quality characteristics and chemical compositions were analyzed in two age groups (3~4 ,7~8 years old).

Result: The shear force, fat, energy, iron, manganese, methionine, myristic acid, palmitic acid, vitamin E and hypoxanthine contents of camel meat significantly increased with age, while moisture, glutamic acid, glycine, proline, stearic acid, linoleic acid, cis-11,14,17-dodecatrienoic acid and cis-13,16-docosa-2-dienoic acid contents decreased with age. In comparison to the meat of grass-feeding livestock such as cattle and sheep, Alxa bactrian camel meat is characterized by low cholesterol, low fat, high calcium, high sodium, selenium enrichment and high L-carnitine.

Key words: Alxa bactrian camel, Chemical composition, Meat quality.

INTRODUCTION

The family Camelidae comprises two subfamilies: the Old World Camelidae and the New World Camelidae. Within the genus Camelus, there are two species of camels the dromedary and the bactrian camel (Faye, 2015). The dromedary camels are widely distributed in the hot and arid regions of the Middle East and Africa, while the bactrian camels are found in the cold and arid regions of Central and East Asia. The original purpose of camels was for milk production by females and transportation by males. Later, they became valuable livestock for meeting the meat and milk needs of inhabitants in arid and semi-arid regions due to their cost-effective survival and high productivity in harsh environments (Djenane and Aider 2022; Bhakat and Patil, 2014; Yang *et al*., 2023).

According to the Food and Agriculture Organization of the United Nations (FAO) in 2020, there are more than 34 million dromedary camels and over 1 million bactrian camels worldwide. China, as reported in the China Statistical Yearbook 2023, has 541,400 bactrian camels, with approximately 200,000 belonging to the Alxa bactrian camel breed. This constitutes 36.94% of the total camel population in the country, establishing it as one of the primary bactrian camel breeds in China. The Alxa region in China serves as the primary production area for the Alxa bactrian camel and is renowned as the “Chinese camel town” (Fig 1). The landscape of Alxa region is characterized by Gobi, Deserts, Desert steppe and Mountainous areas, contributing to variations in the physical characteristics of

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camels distributed across different regions during the extensive process of natural evolution (Fig 2). For instance, camels inhabiting the Gobi region tend to be large, possessing well-developed skeletal muscles and predominantly tan fur. In contrast, camels residing in the Desert region are smaller, featuring fine downy hairs and predominantly apricot-yellow fur.

Traditional camel meat consumed is often derived from older or retired camels, resulting in meat that is tough, leaving consumers with impressions of dry, tough and coarse texture (Bokor *et al.,* 2023). However, in-depth research on camels has revealed that camel meat of the right age is an ideal animal food, exhibiting high moisture, high protein, low fat and low cholesterol content (Kadim *et al.,* 2008). Currently, worldwide research on camel meat is predominantly focused on the dromedary camel, with limited attention given to the meat of the Bactrian camel.

In this study, our research team conducted an investigation into the slaughtering performance and muscle characteristics of Alxa Bactrian camels, determining the peak age for the growth of skeletal muscles in Alxa bactrian camels to be 8 years old(Wenfang *et al.,* 2019). Based on the above findings, research samples were randomly selected from the Alxa Gobi, Desert, Desert Steppe and Mountainous areas, covering two age groups: weaned camels (3~4 years old) and young camels (7~8 years old). The meat quality and chemical composition of these samples were analyzed to comprehensively evaluate the quality and nutritional components of Alxa Bactrian camel meat. The aim is to contribute to the promotion and marketing of camel meat in the market.

MATERIALS AND METHODS

Sample collection

The experiment was carried out in the laboratory of College of Veterinary Medicine, Inner Mongolia Agricultural University and Inner Mongolia Agriculture, Amimal Husbandry, Fishery and Biology Experiment Research Centre from January 2022 to December 2023.



Fig 1: Alxa map.

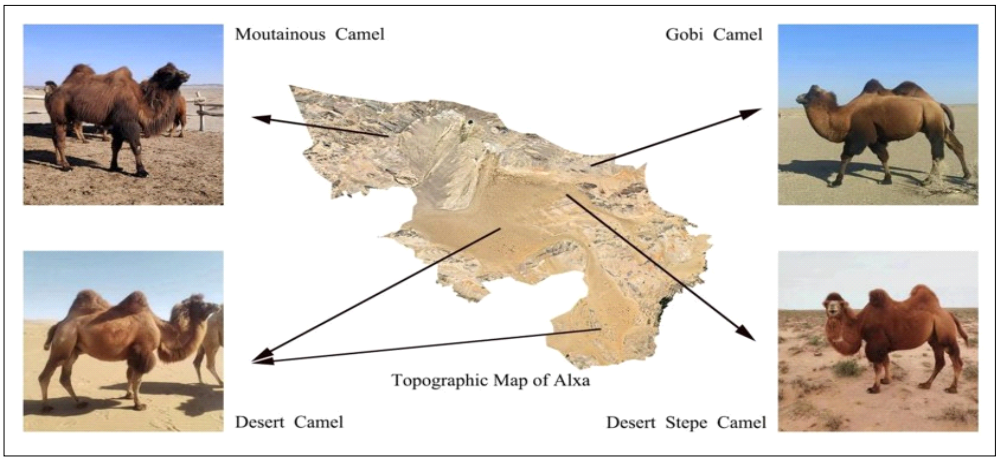


Fig 2: Alxa bactrian camel.

The samples for this study were randomly selected from diverse environments, including the Alxa Gobi, Desert, Desert steppe and Mountainous areas, based on the age criteria of 3~4 years old and 7~8 years old bactrian camels. Each age group consisted of 6 individuals, amounting to a total of 48 peaks. The samples were then categorized into two groups: weaned camels (3~4 years old, n=24) and young camels (7~8 years old, n=24). Each bactrian camel yields approximately 6 kg of fresh meat from the longest muscle in the loin. This meat sample is divided into two portions. One portion undergoes immediate quality testing upon slaughter, while the other is placed in a sealed bag, labeled and transported frozen to the laboratory, where it is stored at -20°C until further chemical composition analysis.

Meat quality measurement

Before further processing, the collected samples were stored at a low temperature of 4°C for 24-48 hours. Subsequently, most visible fat, tendon and connective tissues were excised for the determination of various meat quality indices, including meat color, pH, drip loss rate, cooked meat rate, water loss rate and shear force.

Meat color

Meat color attributes, including brightness (L*), redness (A*) and yellowness (B*), were measured using an SC-80C type automatic colorimeter. Three measurements were taken for each sample and the averages were recorded.

pH measurement

The pH-STAR portable pH meter was used to measure the pH along the central axis of the longest muscle in the back from head to tail at three points. The pH meter was inserted into the muscle at a depth of 0.5 to 1 cm to determine the pH value. Measurements were taken three times at 45 minutes and 24 hours and the average value was calculated.

Drip loss rate

A long meat sample was weighed and then hung in a wide-mouth bottle with muscle fibers facing downward. After 24 hours, the sample was removed and reweighed to determine the drip loss rate using the formula:

$$\text{Drip loss rate} = \frac{\text{Weight of meat sample before} - \text{Weight of meat sample after drip}}{\text{Weight of meat sample before}} \times 100\%$$

Water loss rate

A cake-shaped meat sample, about 1 cm thick, was pressed between layers of gauze and filter paper using a Bulader-M10 meat press at 35 kg pressure for 5 minutes. The water loss rate was calculated using the formula:

$$\text{Water loss rate} = \frac{\text{Weight of meat sample before pressing} - \text{Weight of meat sample after pressing weight}}{\text{Weight of meat sample before pressing}} \times 100\%$$

Cooked meat rate

Meat samples were sealed in bags, cooked in a constant temperature water bath at 80°C until the center temperature reached 80°C and then weighed after surface water absorption. The cooked meat rate was calculated using the formula:

$$\text{Cooked meat rate} = \frac{\text{Weight of meat sample before cooking} - \text{Weight of meat sample after cooking}}{\text{Weight of meat sample before cooking}} \times 100\%$$

Shear force

Cooked meat samples, cut into 1.5×1.5×5 cm strips in the direction of muscle fibers, were subjected to shear force determination using the C-LM3B type tenderness instrument. Measurements were taken at intervals of 1 to 1.5 cm along transverse muscle fibers and the average value was recorded after three measurements.

Moisture

Moisture content was determined using the direct drying method.

Fat

Fats were extracted using the Soxhlet extraction method.

Protein

Proteins content was assessed using the Kjeldahl method.

Ash

Ash content was determined by total food ash determination, involving ashing in a muffle furnace at 500°C for 24 hours.

Mineral content

Mineral content, including potassium, sodium, calcium, magnesium, copper, iron, manganese and zinc, was analyzed using flame atomic absorption spectrometry; The detection of phosphorus utilizes the molybdenum blue spectrophotometric method; Selenium content was determined using hydride atomic fluorescence spectrometry.

Amino acid content

Amino acid content in the muscle was determined in accordance with the national standard GB 5009.124-2016. Additionally, tryptophan was assessed using fluorescence pre-treatment and detected by high-performance liquid chromatography, referencing both GB 15400-2018.

Fatty acid composition

The determination of fatty acid composition followed the area normalization method outlined in GB 5009.168-2016.

Vitamin

Vitamins A and E were detected using reversed-phase high-performance liquid chromatography (RP-HPLC). Vitamins B1 and B2 were determined using fluorescence spectrophotometry.

Additional analyses

Total cholesterol was determined using high-performance liquid chromatography (HPLC); Crude protein was assessed by Foss Tecator Kjeltec 2300 Nitrogen/Protein Analyzer; L-carnitine content was determined based on the "Health Food Inspection and Technical Specification (2003 Edition)". Inosinic acid was analyzed using high-performance liquid chromatography (HPLC). Nucleotide content was analyzed by reversed-phase ion-pair high-performance liquid chromatography (RP-IP-HPLC).

Statistics and data analysis

The collected data were organized using Excel 16.0 and subjected to statistical analysis through One-Way ANOVA using SPSS 26.0 software. Results were presented as "mean ± standard deviation," with significance levels set at $p<0.05$ indicating significant differences and $p>0.05$ indicating insignificant differences.

RESULTS AND DISCUSSION

Determination results of meat quality characteristics

In the assessment of meat quality-related parameters (Table 1), it was observed that the shear force of weaned camel meat was significantly lower than that of young camels ($p<0.05$). Additionally, pH45 min, drip loss rate and water loss rate were lower in weaned camels compared to young camels, although the differences were not statistically significant ($p>0.05$).

Results of routine meat analysis

The moisture content in weaned camels was significantly higher than that in young camels. Additionally, there was a tendency for the protein content to be higher in weaned camels, although the difference did not reach statistical significance ($p>0.05$). The fat content in young camels was significantly higher than that in weaned camels ($p<0.05$). The ash content remained essentially unchanged between the two age groups (Table 2).

Analysis results of mineral element content

The potassium and Phosphonium content in weaned camels was significantly higher than that in young camels ($p<0.05$). Sodium, magnesium and selenium content in weaned camels were higher than in young camels, although the differences were not statistically significant ($p>0.05$). Iron and manganese content in young camels were significantly higher than in weaned camels ($p<0.05$). Calcium, copper and zinc content in young camels were higher than in weaned camels, but the differences were not statistically significant ($p>0.05$) (Table 3).

Results of amino acid content analysis

Lysine constituted the largest proportion among the essential amino acids. Arginine held a larger share of the semi-essential amino acids.Glutamic acid and aspartic acid dominated among the non-essential amino acids. Notably, in weaned camels: Glycine and proline were significantly higher than in young camels ($p<0.05$). Methionine,

Table 1: Results on meat quality of Alxa bactrian camel (n=24, Mean ± SE).

Age (year)	Brightness (L*)	Redness (A*)	Yellowness (B*)	pH-45h	pH-24h	Water loss rate %	Shear force kg•N	Drip loss rate %	Cooked meat rate %
Overall	35.19±8.6	27.01±4.63	21.38±6.06	6.47±0.28	6.14±0.18	2.83±1.37	8.57±1.96	25.74±0.08	45.39±0.03
Weaned camel	36.53±8.93	27.41±4.81	22±5.82	6.45±0.3	6.16±0.2	2.79±1.24	7.31±1.39[a]	24.71±0.07	45.68±0.03
Young camel	33.86±8.04	26.61±4.41	20.77±6.22	6.49±0.26	6.12±0.15	2.87±1.5	9.83±1.61[b]	26.78±0.09	45.1±0.03

Means in the same column with different superscript are significantly different ($P<0.05$).

conversely, was significantly lower than in young camels ($p<0.05$) (Table 4).

Results of fatty acid content analysis

Eight saturated fatty acids were detected, constituting a total content of 49.06%. Palmitic acid (24.204%) and stearic acid (15.712%) held the highest percentage, with heneicosanoic acid (C21:0) found exclusively in the muscles of young camels. Eight unsaturated fatty acids were detected, with a total content of 46.78%. This included 30.87% monounsaturated fatty acids and 15.91% polyunsaturated fatty acids. Oleic acid (27.536%) dominated among monounsaturated fatty acids, while linoleic acid (9.628%) had the highest percentage among polyunsaturated fatty acids. Observations from the results indicated that.

Saturated fatty acids C14:0 (myristic acid) and C16:0 (palmitic acid) in weaned camel meat were significantly lower than in young camel meat ($p<0.05$). Saturated fatty acid C18:0 (stearic acid) in weaned camel meat was significantly higher than in young camel meat ($p<0.05$). Polyunsaturated fatty acids C18:2n6c, C20:3n3 and C22:2 content decreased significantly with age ($p<0.05$) (Table 5).

Results of content analysis of other indicators

Vitamin E content in young camel meat was significantly higher than in weaned camel meat ($p<0.05$). Vitamin B1 and vitamin B2 content in young camel meat were higher than in weaned camel meat, although the differences were not statistically significant ($p>0.05$). Vitamin A content in weaned camel meat was higher than in young camel meat, but the difference was not statistically significant ($p>0.05$). Hypoxanthine content in weaned camel meat was significantly lower than that in young camel meat ($p<0.05$). Adenine and guanine content tended to increase with age, although the differences were not statistically significant ($p>0.05$). Cytosine and uracil content decreased with age, but the differences were not statistically significant ($p>0.05$). The content of nucleotides in the muscles of Alxa bactrian camel followed this order: cytosine > guanine > uracil > hypoxanthine > adenine. The content of inosinic acid decreased with age, but the difference was not significant.

The energy content of young camels was significantly higher than that of weaned camels ($p<0.05$). The content of L-carnitine and total cholesterol decreased with age, although the differences were not statistically significant ($p>0.05$) (Table 6).

Meat quality

Meat quality plays a pivotal role in consumer perception and acceptability. Meat color, an influential factor in sensory evaluation, significantly impacts consumers' willingness to purchase (Tomasevic *et al.,* 2021). The brightness (L*), redness (A*) and yellowness (B*) indicators of weaned camel meat were observed to be higher than those of young camel meat,although the differences were not statistically significant.The variation in meat color is attributed to myoglobin content, Fe element redox and fat oxidation (Karamucki *et al.,* 2013; Swatland, 1982; Kadim *et al.,* 2013).

pH value, a crucial indicator of meat quality, affects tenderness, hydration and color (Watanabe *et al.,*1996; Molinero *et al.,* 2024). A decrease in pH value may also lead to protein denaturation (Molinero *et al.,*2024). In the current investigation, the pH values of weanlings and young camels 24 hours after slaughter were observed to be lower than the pH values at 45 minutes, indicating a declining trend. This trend aligns with the pH-time graph of dromedary camel muscle observed in Kadim's study (Kadim *et al.,* 2013). It is important to note that the ultimate pH value of meat is influenced by various factors, including pre-slaughter treatment, post-slaughter processing and the physiological condition of the muscle, among others(Araújo *et al.,* 2020).

Shear force is a primary physical method used to assess meat tenderness, a crucial indicator of meat quality. In this study, the shear force of young camel meat was found to be significantly higher than that of weanling camel meat, consistent with findings in dromedary camel meat studies (Kadim *et al.,* 2006; Suliman *et al.,* 2020). This discrepancy in tenderness can be attributed to the collagen content in the muscle connective tissue(Cross *et al.,* 2010). Hydroxyproline, found in collagen, serves as a key indicator for assessing muscle connective tissue and higher concentrations of hydroxyproline are associated with decreased meat tenderness (Berry *et al.,* 1974). The content of muscle, including hydroxyproline, varies significantly among different breeds, ages and anatomical regions of the body (Seideman, 1986).

A lower drip loss and water loss rate are indicative of better water-holding capacity in muscle, while a higher cooked meat rate suggests greater water retention. The findings of this study reveal that young camel meat exhibited higher drip loss and water loss rates compared to weanlings. Conversely, the cooked meat rate was lower in young camels than in weanlings, aligning with results reported by Rendalai (Si *et al.,* 2022). This suggests that weanling camel meat possesses greater water retention, tenderness and juiciness.

Nutritional composition

The nutritional composition of meat is a crucial aspect and the protein, moisture, fat and ash content of Alxa bactrian

Table 2: Determination results of routine indexes of Alxa bactrian camel meat (n=24, Mean ± SE).

Age (year)	Protein %	Fat %	Ash %	Moisture %
Overall	18.35±1.04	6.07±3.15	1.19±0.2	74.4±3.06
Weaned camel	18.5±0.96	4.24±1.79^{a}	1.19±0.2	76.16±1.59^{b}
Young camel	18.2±1.1	7.90±3.16^{b}	1.19±0.2	72.64±3.16^{a}

Means in the same column with different superscript are significantly different ($P<0.05$).

Table 3: Test results of mineral elements in Alxa bactrian camel meat (n=24, Mean ± SE).

Age (year)	Postassium %	Phosphonium%	Sodium mg/100 g	Calaium mg/kg	Magnesium mg/kg	Copper mg/kg	Iron mg/kg	Manganese mg/kg	Zinc mg/kg	Selenium ug/kg
Overall	0.35±0.03	0.185±0.02	142.275±148.88	321.23±64.42	212.27±31.42	0.665±0.15	15.915±3.41	0.205±0.05	55.84±9.44	93.1±33.5
Weaned camel	0.36±0.02^{b}	0.19±0.01^{b}	143.19±176.74	310.16±73.77	215.98±41.84	0.66±0.17	14.44±3.02^{a}	0.19±0.05^{a}	54.83±9.69	97.09±31.45
Young camel	0.34±0.03^{a}	0.18±0.02^{a}	141.36±114.42	332.3±51.85	208.56±14.45	0.67±0.12	17.39±3.2^{b}	0.22±0.05^{b}	56.85±9.26	89.11±35.29

Means in the same column with different superscript are significantly different (P<0.05).

Table 4: Test results of amino acid content (%) in Alxa bactrian camel meat (n=24, Mean ± SE).

Age (year)	Lys	Leu	Val	Thr	Ile	Phe	Met	Trp	Arg
Overall	1.411±0.08	1.329±0.08	0.794±0.04	0.743±0.04	0.72±0.04	0.653±0.04	0.386±0.05	0.2301±0.02	1.034±0.06
Weaned camel	1.426±0.07	1.332±0.07	0.794±0.03	0.748±0.04	0.719±0.04	0.655±0.04	0.367±0.05^{a}	0.2282±0.02	1.048±0.05
Young camel	1.395±0.08	1.325±0.08	0.793±0.05	0.739±0.05	0.72±0.05	0.651±0.04	0.405±0.05^{b}	0.2313±0.02	1.019±0.07
	His	**Gln**	**Asp**	**Ala**	**Gly**	**Pro**	**Ser**	**Tyr**	**Cys**
Overall	0.614±0.07	2.499±0.14	1.504±0.09	0.945±0.05	0.719±0.06	0.628±0.05	0.621±0.04	0.577±0.04	0.347±0.03
Weaned camel	0.607±0.06	2.526±0.13	1.511±0.07	0.956±0.05	0.744±0.05^{b}	0.642±0.75^{b}	0.628±0.03	0.575±0.03	0.343±0.03
Young camel	0.621±0.07	2.472±0.15	1.497±0.1	0.934±0.06	0.694±0.06^{a}	0.614±0.05^{a}	0.613±0.04	0.578±0.04	0.351±0.03
			TAA	**NEAA**	**EAA/TAA**	**EAA/NEAA**			
Weaned camel			15.754	9.488	39.77	66.04			
Young camel			15.849	9.58	39.56	65.44			
Overall			15.652	9.393	39.99	66.64			

TAA:Total amino acids; EAA:Essential amino acids; NEAA :Non-essential amino acids; Lys: Lysine; Leu: Leucine; Val: Valine; Thr: Threonine; Ile: Isoleucine; Phe: Phenylalanine; Met: Methionine; Trp: Tryptophane; Arg: Argnine; His: Hlstidine; Gln: Glutamine; Asp: Aspartic acid; Ala: Alanine; Gly: Glycine; Pro: Proline; Ser: Serine; Tyr: Tyrosine; Cys: CyStinum; Means in the same column with different superscript are significantly different (P<0.05).

Table 5: Test results of fatty acid composition (%) in Alxa bactrian camel meat (n=24, Mean ± SE).

Age (year)	C4:0	C12:0	C14:0	C15:0	C16:0	C17:0	C18:0	C21:0
Overall	0.475±0.1	0.43±0.13	5.061±1.17	1.839±0.9	24.204±2.23	0.727±0.23	15.712±2.55	0.615±0.08
Weaned camel	0.475±0.1	0.381±0.11	4.392±1.06^{a}	2.09±0.85	22.895±1.82^{a}	0.788±0.27	17.133±2.52^{b}	ND±ND
Young camel	0.475±0.09	0.421±0.15	5.730±0.83^{b}	1.599±0.87	25.513±1.8^{b}	0.668±0.17	14.291±1.61^{a}	0.615±0.08
	C16:1	**C17:1**	**C18:1n9c**	**C18:2n6c**	**C18:3n3**	**C20:3n6**	**C20:3n3**	**C22:2**
Overall	1.058±0.95	2.272±0.97	27.536±3.21	9.628±2.07	1.848±0.54	0.353±0.25	3.283±1.05	0.797±0.33
Weaned camel	1.001±0.77	2.479±0.85	26.825±2.88	10.218±2.23^{b}	1.953±0.65	0.405±0.29	3.641±1.2^{b}	0.923±0.36^{b}
Young camel	1.114±1.09	2.066±1.05	28.246±3.36	9.037±1.69^{a}	1.742±0.37	0.299±0.2	2.924±0.72^{a}	0.677±0.26^{a}
			SFA	**UFA**	**MUFA**	**PUFA**		
Overall			49.063	47.445	30.866	15.909		
Weaned camel			48.154	46.105	30.305	17.14		
Young camel			48.891	46.775	31.426	14.679		

SFA: Saturated fatty acid; MUFA: Mono-unsaturated fatty acids; PUFA: Poly-unsaturated fatty acids; SFA: Total saturated fatty acids; UFA: Total unsaturated fatty acids.Butyric acid (C4:0); Lauric acid (C12:0); Myristic acid (C14:0); Pentadecanoic acid (C15:0); Palmitic acid (C16:0); Heptadecanoic acid (C17:0); Stearic acid (C18:0); Heneicosanoic acid (C21:0); Palmitoleic acid (C16:1); Cis-10-heptadecenoic acid (C17:1); Oleic acid (C18:1n9c); Linoleic acid (C18:2n6c); α -linolenic acid (C18:3n3); Cis-8,11,14-eicosatrienoic acid(C20:3n6); Cis-11,14,17-Eicosatrienoic acid (C20:3n3); Cis-13,16-docosadienoic acid (C22:2); Means in the same column with different superscript are significantly different (P<0.05).

camel muscle align with findings in dromedary meat studies (Kadim *et al.,* 2006; Kadim *et al.,* 2013). Notably, the fat content in the muscle of young Alxa bactrian camels was significantly higher than that of weanling camel, while the moisture content was significantly lower. This corresponds with the general observation that moisture in meat is negatively correlated with intramuscular fat content (Wen *et al.,* 2020). The protein content of Alxa bactrian camel meat is 18.35%, similar to that of dromedary camel meat (Kadim *et al.,* 2013). As the age increases, the fluctuation in protein content of Alxa bactrian camel meat ranges from 18.2% to 18.5%, falling within the fluctuation range of dromedary camel meat (17% to 23.7%) (Kadim *et al.,* 2013; Watanabe *et al.,* 1996). The fat content in Alxa bactrian camel meat is influenced by age, with the muscle fat content of young camels significantly higher than that of weaned camels, at 6.07%, which is higher than the fat content in other bactrian camel muscles at 5.21% (Suliman *et al.,* 2020), but similar to the fat content in dromedary camel meat at 6.20% (Kadim *et al.,* 2013).

Combining the above information, Alxa bactrian camel meat is a healthy meat with high protein, high moisture and low fat content. As age increases, the fat content rises, while protein and moisture decrease.

Mineral elements

In the muscle tissue of Alxa bactrian camels, calcium, magnesium, sodium and zinc content are higher than in dromedary camels (Kadim *et al*., 2008), making it a good source of these minerals. Research results indicate that the potassium content in weaned camel muscle is significantly higher than in young camels, while the iron and manganese content in young camel muscle is significantly higher than in weaned camels. This suggests that with increasing age, the levels of iron and manganese in the muscle tissue of Alxa bactrian camels also increase. The study results indicate that potassium content in the muscle of weaned camels is significantly higher than in young camels. Conversely, iron and manganese content in the muscle of young camels is significantly higher than in weaned camels, suggesting an age-related increase in iron and manganese content in Alxa bactrian camel muscle.

Skeletal muscle is the main storage site for selenium, with 28-46% of selenium deposited in skeletal muscle (Raiymbe *et al.,* 2019). Therefore, it is representative to study the selenium content in skeletal muscle. The average selenium content in this study was 9.3 μg/100 g and is higher than that of dromedary camel muscle selenium of 4 μg/100 g (Djenane and Aider, 2022).

The selenium content in animal bodies is closely related to the selenium content in their food, depending on the geographic origin of the soil, soil pH and the type of plants (Gierus *et al.,* 2002). It has been reported that Algerian camels are a good source of selenium in human diets. Therefore, selenium-rich meat can have a positive impact on human health.

Amino acid

The amino acid content and ratio in meat products of livestock and poultry can reflect their nutritional value(Sang-Woo *et al.,* 2016). The ideal protein pattern recommended by FAO/WHO is EAA/TAA and EAA/NEAA ratios of over 40% and 60%, respectively. In this study, the proportions of essential amino acids to total amino acids (EAA/TAA) and the ratio of essential amino acids to non-essential amino acids (EAA/NEAA) in Alxa bactrian camel meat were found to be 39.8% and 79.9%, respectively. These values align with the FAO/WHO ideal protein pattern. The results are similar to those of the Rendalai study, where EAA/TAA ranged from 39.61% to 69.97%, but higher than their EAA/NEAA results of 65.59% to 66.58%. Amino acids can be classified based on taste characteristics into umami, sweet, bitter and tasteless amino acids (Han *et al.,* 2011). Alxa bactrian camel meat exhibits a high content of umami amino acids (4.971%), with the weaned camels showing higher levels compared to young camels. Sweet amino acids not only provide sweetness but also, to some extent, reduce bitterness and enhance overall freshness of the product. The total content of sweet amino acids in Alxa bactrian camel meat is 3.028%, with proline (0.945%) being the highest and glycine significantly higher in weaned camels than in young camels.

Fatty acids

In this study, the saturated fatty acid content is 49.06% and the unsaturated fatty acid content is 46.78%. The proportion of polyunsaturated fatty acids (PUFA) is in the range of 14.679% to 17.14%, which is higher than that in dromedary camels (11.44% to 12.82%) (Kadim *et al.,* 2013) and beef (4.39%) (Tao *et al.,* 2020). The PUFA/SFA ratio is used to evaluate the nutritional value of meat, with a recommended value of 0.4 by nutrition experts. In this study, the PUFA/SFA ratio in Alxa bactrian camel meat is 0.32, while in dromedary camels, it ranges from 0.22 to 0.26 and in beef and lamb, it is approximately 0.1. Considering this evaluation method, the PUFA/SFA ratio in Alxa bactrian camel meat is closer to the recommendedvalue by experts (Si *et al.,* 2022). Additionally, the content of PUFA in weaned camel meat is higher than that in young camel meat. This indicates that the ratio of essential fatty acids, linoleic acid and α-linolenic acid, is higher in Alxa bactrian camel meat compared to dromedary camels (Kadim *et al.,* 2013) and beef (3.44% and 0.27%). The proportion of α-linolenic acid in the muscle is lower than that of linoleic acid. This is because most of these two fatty acids in the feed are biohydrogenated in the rumen into saturated fatty acids and monounsaturated fatty acids, with a greater degree of hydrogenation for α-linolenic acid (Wood *et al.,* 2013). With increasing age, the proportion of polyunsaturated fatty acids in the muscle decreases and the proportions of the two essential fatty acids also decrease. In addition, age has a significant impact on the content of myristic acid, palmitic acid, stearic acid, cis-11,14,17-eicosatrienoic acid and cis-13,16-docosadienoic acid in the muscle.

Table 6: Results of other indexes of Alxa bactrian camel meat (n=24, Mean ± SE).

Age (year)	Vitamin A mg/100 g	Vitamin E mg/100 g	Vitamin B1 mg/100 g	Vitamin B2 mg/100 g	Cytosine (CMP) mg/100 g	Adenine (AMP) mg/100 g	Uracil (UMP) mg/100 g
Overall	0.0938±0.2	0.5273±0.2	0.0736±0.02	0.1116±0.02	7.42±2.48	0.208±0.43	0.588±0.47
Weaned camel	0.1272±0.28	0.4181±0.15^{a}	0.0753±0.02	0.1084±0.02	7.917±2.05	0.148±0.07	0.614±0.42
Young camel	0.0604±0.04	0.6364±0.19^{b}	0.0719±0.02	0.1148±0.02	6.922±2.75	0.269±2.75	0.563±0.52
	Guanine (GMP) mg/100g	**Hypoxanthine (Hx) mg/100 g**	**Inosinic acid (IMP) mg/100 g**	**Energy KJ/g**	**L-carnitine mg/100 g**	**Total cholesterol mg/100 g**	
Overall	0.764±0.3	0.579±2.11	34.22±23.07	6.48±1.18	354.9±141.14	39.34±4.55	
Weaned camel	0.723±0.31	0.377±0.36^{a}	30.87±16.38	5.78±0.65^{a}	372.8±157.52	40.59±4.55	
Young camel	0.806±0.29	0.781±2.95^{b}	37.57±27.81	7.18±1.19^{b}	336.9±119.95	38.09±4.19	

Means in the same column with different superscript are significantly different ($P<0.05$).

Other indicators

In this study, the content of vitamin A and B1 in Alxa bactrian camel meat was relatively higher compared to cattle and sheep(Williams, 2007), while the vitamin B2 content was lower than that in beef and mutton. The vitamin E content in Alxa bactrian camel meat (0.53 mg/100 g) was higher than that in mutton (0.44 mg/100 g) but lower than that in beef (0.63 mg/100 g). The vitamin E content in the meat of young camels was significantly higher than in weaned camels and with age, there was an accumulated increase in vitamin E in the muscles. Therefore, Alxa bactrian camel meat is considered high-quality red meat with a higher vitamin content.

Low nucleotide content in meat of Alxa bactrian camel. As seen in Table 6, Inosinic acid had the highest concentration in camel meat, contributing significantly to its flavor. The flavor intensity was higher in young camels compared to weaned camels. Given the limited research on nucleotides in camel meat, this study provides valuable data to support future comprehensive investigations.

The L-carnitine content in the muscle of Alxa bactrian camel was 354 mg/100 g, which was higher than that of lamb (200 mg/100 g) (Pekala *et al.,* 2011) and beef (130 mg/100 g) (Arihara, 2006). In France, a per capita meat consumption of 88.2 kg annually is sufficient to meet the body's carnitine requirements Thus, Alxa bactrian camel meat serves as a valuable source of L-carnitine (Shimada *et al.,* 2004; Mamani-Linares *et al.,* 2013).

Studies indicate that L-carnitine content in animal muscle increases with age. Beef L-carnitine content peaks at 32-36 months, the ideal slaughter age for beef cattle (Shimada *et al.,* 2004). From this study, it is evident that the L-carnitine content in weaned camels is higher than that in young camels, although the difference is not significant. Therefore, the muscle of weaned camels may represent a more suitable source of L-carnitine compared to young camels, suggesting that the L-carnitine content in Alxa bactrian camel muscle may peak during the weaning period.

The cholesterol content in Alxa bactrian camel muscle, at 39.34 mg/100 g, is lower than levels detected in dromedary camel meat by I.T. Kadim (Kadim *et al.,* 2008) (50-59 mg/100 g) and is similar to that of American camels (39.04 mg/100 g). Additionally, it is lower than cholesterol levels found in cattle and sheep(Salvatori *et al.* ,2004; Su *et al.,* 2022). Given the potential link between excessive cholesterol intake and various health issues, Alxa Bactrian camel meat stands out as a healthy food option with low cholesterol compared to other animals.

CONCLUSION

The following conclusions have been drawn from the analysis and study:

1. Alxa bactrian camel meat stands out as a high-quality meat compared to other varieties. It is characterized by low fat, low cholesterol, low energy content, high sodium, high calcium and richness in selenium, L-carnitine, amino acids and unsaturated fatty acids. This makes it a nutritious and healthy choice.
2. The meat characteristics and chemical composition of different parts of Alxa bactrian camels varied to different degrees across different ages.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Ethics

The study was approved by the Specialized Committee on Scientific Research and Academic Ethics and Morality of Inner Mongolia Agricultural University (No.2020002) and strictly adhered to animal welfare and ethical guidelines. Informed consent was obtained from all subjects involved in the study.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

REFERENCES

Araújo, J., Lima, A., Nunes, M., Sousa, M., Serrão, G., Morais, E., Daher, L., Silva, A. (2020). Relationships among carcass shape, tissue composition, primal cuts and meat quality traits in lambs: A PLS path modeling approach. *Small Ruminant Research*. **182:** 52-66.

Arihara, K. (2006). Strategies for designing novel functional meat products. *Meat Science*. **74(1):** 219-229.

Berry, B.W., Smith, G.C., Carpenter, Z.L. (1974). Relationships of certain muscle, cartilage and bone traits to tenderness of the beef longissimus. *Journal of Food Science*. **39(4):** 819-824.

Bhakat, C., Patil, N.V. (2014). Studies on utilization pattern of camel and tractor in hot arid desert ecosystem. *Indian Journal of Animal Research*. **48(5):** 486-490. doi: 10.5958/0976-0555.2014.00016.8.

Bokor, J., Nagy, J., Donkó, T., Horn P., Bokor, Á. (2023). The effect of age and sex on carcass traits and body composition of hungarian yearling farmed red deer (*Cervus elaphus hippelaphus*). *Meat Science*. **204:** 109290.

Cross, H.R, Smith, G.C., Carpenter, Z.L.(2010). Palatability of individual muscles from ovine leg steaks as related to chemical and histological traits. *Journal of Food Science*. **37(2):** 282-285.

Djenane, D, Aider, M. (2022). The one-humped camel: The animal of future, potential alternative red meat, technological suitability and future perspectives. *F1000Res*. **5(11):** 1085-1085.

Faye, B.R. (2015). Distribution and perspective of camel breeding in the third millennium economies. *Emirates Journal of Food and Agriculture*. **4:** 318-327.

Gierus, M., Schwarz, F.J., Kirchgessner, M. (2002). Selenium supplementation and selenium status of dairy cows fed diets based on grass, grass silage or maize silage. *Journal of Animal Physiology and Animal Nutrition*. **86(34):** 74-82.

Han, F.L., Xu Y.(2011). Identification of low molecular weight peptides in Chinese rice wine (Huang Jiu) by UpLC ESI MS/MS. *Journal of the Institute of Brewing*. **117(2):** 238-250.

Hariharan, S., Dharmaraj, S. (2020). Selenium and selenoproteins: It's role in regulation of inflammation. *Inflammopharmacology*. **28(3):** 667-695.

Kadim, I.T., Al-Karousi, A., Mahgoub, O., Al-Marzooqi, W., Khalaf S.K., Al-Maqbali, R.S., Al-Sinani, S.S.H., Raiymbek, G. (2013). Chemical composition, quality and histochemical characteristics of individual dromedary camel (*Camelus dromedarius*) muscles. *Meat Science*. **93(3):** 564-571.

Kadim, I.T., Mahgoub, O, Al-Marzooqi, W., Al-Zadjali, S., Annamalai, K., Mansour, M.H. (2006). Effects of age on composition and quality of muscle *Longissimus thoracis* of the Omani Arabian camel (*Camelus dromedaries*). *Meat Science*. **73(4):** 619-625.

Kadim, I.T., Mahgoub, O., purchas, R.W. (2008). A review of the growth, and of the carcass and meat quality characteristics of the one-humped camel (*Camelus dromedaries*). *Meat Science*. **80(3):** 555-569.

Karamucki, T., Jakubowska, M., Rybarczyk, A., Józefa, G. (2013). The influence of myoglobin on the colour of minced pork loin. *Meat Science*. **94(2):** 234-238.

Mamani-Linares, L.W., Gallo, C.B. (2013). Meat quality attributes of the Longissimus lumborum muscle of the Kh'ara genotype of llama (*Lama glama*) reared extensively in Northern Chile. *Meat Science*. **94(1):** 89-94.

Molinero, E., Pena, R.N., Estany, J., Freixedes, R.R. (2024). A novel QTL region for pH and meat color in duroc pigs. *Animal Genetics*. **55(3):** 465-470. doi: 10.1111/age.13426.

Pekala, J., Patkowska-Sokola, B., Bodkowski, R., Jamroz, D., Nowakowski, P., Lochyński, S., Librowski, T. (2011). L-carnitine-metabolic functions and meaning in humans life. *Current Drug Metabolism*. **12(7):** 667-678.

Raiymbek, G., Faye, B., Kadim, I.T., Serikbaeva, A., Konuspayeva, G. (2019). Comparative fatty acids composition and cholesterol content in Bactrian (*Camelus bactrianus*) and dromedary camel (*Camelus dromedarius*) meat. *Tropical animal Health and Production*. **51(7):** 2025-2035.

Salvatori, G., Pantaleo, L., Cesare, C.D., Maiorano, G., Filetti, F., Oriani, G. (2004). Fatty acid composition and cholesterol content of muscles as related to genotype and vitamin E treatment in crossbred lambs. *Meat Science*. **67(1):** 45-55.

Sang-Woo, K., Kwan-Woo, K., Seong-Bok, P., Myung-Jick, K., Dong-Gyun, Y. (2016). Quality characteristics and composition of the muscle from entire and castrate elk in Korea. *Asian-Australasian Journal of Animal Sciences*. **29(5):** 709-715.

Seideman, S.C. (1986). Methods of expressing collagen characteristics and their relationship to meat tenderness and muscle fiber types. *Journal of Food Science*. **51(2):** 273-276.

Shimada, K., Sakuma, Y., Wakamatsu, J., Fukushima, M., Sekikawa, M., Kuchida, K., Mikami, M .(2004). Species and muscle differences in L-carnitine levels in skeletal muscles based on a new simple assay. *Meat Science*. **68(3):** 357-362.

Si, R., Na, Q., Wu, D., Wu, X, Ming, L., Ji, R. (2022). Effects of age and muscle type on the chemical composition and quality characteristics of bactrian camel (*Camelus bactrianus*) meat. *Foods*. **11(7):** 1021.

Su, S., Ni, J.W., Geng, Y.H., Wang, W., Xu., X., Q. (2022). Nutritive value and meat characteristics of sheep fed *Toona sinensis* (a. juss.). *Indian Journal of Animal Research*. **56(11):** 1428-1431. doi: 10.18805/ijar.B-1074.

Suliman, G.M., Al-Owaimer, A.N., Hussein, E.O.S., Abuelfatah, K., Othman, M.B. (2020). Meat quality characteristics of the Arabian camel (*Camelus dromedarius)* at different ages and post-mortem ageing periods. *Asian-Australasian Journal of Animal Sciences*. 33(8): 1332-1338.

Swatland, H.J. (1982). Meat color of pork chops in relation to pH and adductor capacitance of intact carcasses. *Journal of Animal Science*. **54(2):** 264-267.

Tao., H., Si., B., Xu., W., Tu., Y., Diao, Q. (2020). Effect of Broussonetia *papyrifera* L. silage on blood biochemical parameters, growth performance, meat amino acids and fatty acids compositions in beef cattle. *Asian-Australasian Journal of Animal Sciences*. **33(5):** 732-741.

Tomasevic, I., Djekic, I., Furnol, M.F.I., Terjung, N., Lorenzo, J.M. (2021). Recent advances in meat color research. *Current Opinion in Food Science*. **41:** 81-87.

Watanabe, A., Daly, C.C., Devine, C.E. (1996). The effects of the ultimate pH of meat on tenderness changes during ageing. *Meat Science*. **42(1):** 67-78.

Wen, Y., Liu, H., Liu, K., Haiyue, C., Haiguang, M., Xinyang, D., Zhaozheng, Y. (2020). Analysis of the physical meat quality in partridge (*Alectoris chukar*) and its relationship with intramuscular fat. *Poultry Science*. **99(2):** 1225-1231.

Wenfang, yuye, F., Yang, B., Yang, H., Gerelt, B., Bao, H., Narenbatu, Demtu, E. (2019). Comparative studies on slaughter performance and skeletal muscle fiber type of alxa gobi camel and desert camel. *Journal of Camel Practice and Research*. **26(1):** 63-69.

Williams, P. (2007). Nutritional composition of red meat. *Nutrition and Dietetics*. **64:** S113-S119.

Wood, J.D., Enser, M., Fisher, A.V., Sheard, P.R., Richardson, R.I., Hughes, S.I., Whittington, F.M. (2008). Fat deposition, fatty acid composition and meat quality: A review. *Meat Science*. **78(4):** 343-358.

Yang, B., Guo, Z., Liu, P., Er, D. (2023). Bactrian camel (*Camelus bactrianus*) milk exosomes promote glucose consumption in I6 cells. *Indian Journal of Animal Research*. **57(11):** 1480-1484. doi: 10.18805/IJAR.BF-1612.