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Assessing the variability in camel and beef meat quality: Implications for consumer acceptance

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ABSTRACT

This survey aimed to determine the widest possible range in the physicochemical and color values of cattle and camel's meat sold in Egyptian markets (Tanta and Toukh cities), caused by the interactions of various fundamental contributing factors such as age, breed, nutrition, hygiene, and stress. To achieve the survey purpose, all thirty camels and beef *longissimus thoracis* muscle (*LTM*, between 10th-13th ribs) were randomly collected, irrespective of basic contributing criteria such as age, gender, and ration composition. Compared to beef, camel *LTM* showed lower purge loss (3.61% vs. 5.24%) and Warner-Bratzler shear force (5.87 vs. 6.66), but greater pH (6.42 vs. 6.17) and cooking loss (39.51% vs. 32.63%) ($P < 0.05$). Compared to beef, camel meat displayed a considerably lower lightness (L^*) average (38.66 vs. 40.56) ($P < 0.05$). However, the levels of redness (a^*) (15.41 vs 12.66), yellowness (b^*) (7.86 vs 6.83), and chroma (17.34 vs 14.48) were much higher in camel meat than in beef, suggesting that the camel meat was redder but less bright. Lower hue (h°) (26.87 vs. 28.65) values of camel meat corroborate this result ($P > 0.05$). Current study results also confirmed that camel meat is consistently associated with greater pH, cooking loss, and darker red meat, and hence it is unaffected by fundamental contributing factors. However, these parameters' variation and interaction greatly influence purge loss and tenderness. Therefore, to boost consumer acceptance of camel meat as a potential red meat substitute, future manufacturing and marketing promotions may focus on tenderness and purge loss.

1. INTRODUCTION

Proteins are crucial components of the human diet, acting as key agents in cellular healing, immunological manipulation, and the maintenance of muscle integrity (Nasrabadi et al., 2021). By 2050, it is anticipated that animal protein production will increase by roughly 50–73% to meet the demands of the world population that is growing and developing economically (Chiang et al., 2021). Egypt has a major shortfall in red meat production and is around 55% self-sufficient (543,000 tons), which is satisfied by importing from outside, especially beef, accounting for up to 99% of all red meat imports, reaching 21.5 billion pounds and presenting a significant strain on the balance of payments (Kandil et al., 2023).

Dromedaries and Bactrian camels are the two types of camelids; the former are primarily found in hot, arid regions of Africa, the Middle East, and South Asia, while the latter are typically found in China and Central Asia (Raiymbek et al., 2015). People in semi-arid and arid regions need high-quality camel food products like milk and meat because of their distinct physiological traits (Kadim et al., 2008). Camel meat is becoming more and more popular as a cheap, high-quality meat source for humans (Li et al., 2023). Economically, camel meat could lessen Egypt's reliance on imported red meat (Kadim et al., 2013; Kandil et al., 2023). Camel meat is a staple protein source in many arid and semi-arid regions, valued for its unique nutritional profile, including lower fat content, higher moisture levels, and a rich supply of iron and vitamins compared to other red meats (Baba et al., 2021).

In Egypt and around the world, camel meat is a sustainable, nutritious, and culturally significant substitute for traditional red meats. Yet, there are major obstacles to its scalability, consumer acceptance, and infrastructure development (Ashour and Abdel-Rahman, 2022; Kandil et al., 2023).

Quality refers to the attributes of a product that meets the needs and expectations of its users (Liu et al., 2022). Both the quality traits that consumers value and the factors that consumers use to anticipate quality can be significantly impacted by breed, feeding and production system, post-mortem environment, and handling. Cattle raised on pasture have leaner meat with a healthier fatty acid profile, but their meat may be less moist and less tender (depending on the muscle) than that of animals raised intensively (Santos et al., 2021).

With growing interest in alternative protein sources, understanding the comparative sensory and textural qualities of camel meat and beef is critical for improving its acceptance and utilization globally. Existing literature highlights challenges in camel meat's tenderness, flavor, and aroma—the primary sensory traits influencing meat quality—while also identifying opportunities for improvement through postmortem processes, formulation, and blending techniques (Kadim et al, 2013).

A combination of extrinsic (such as processing temperature, storage conditions, and methods of slaughter) and intrinsic (such as protein composition, collagen structure, and metabolic by-products) biochemical factors affect camel

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meat quality attributes like pH, water-holding capacity (WHC), purge loss, and cooking loss. With a focus on breed-dependent and muscle-specific variability, comparative investigations of camel and beef have revealed notable differences in postmortem biochemistry, meat texture, and thermal stability (Hassanien et al. 2022).

Tenderness is a prominent differentiator between camel meat and beef, with camel meat consistently reported as tougher across direct comparisons (Kadim and Mahgoub, 2008; Reza Gheisari et al., 2009; Mohamed et al., 2024).

This study highlights the difference in physicochemical and color attributes in camel and cattle *Longissimus muscle* (*LTM*) sold in Egyptian marketplaces, specifically in Tanta and Toukh cities. To advance the consumer acceptance of camel meat in Egyptian marketplaces, this work would present challenges and offer potential solutions by addressing the maximum ranges of differences in the physicochemical characteristics of camel and cattle meat that could result from the interaction of important contributing factors.

2. MATERIAL AND METHODS

2.1. Experiment management and approval.

The methods employed in this work were authorized by the Institutional Animal Care and Use Committee Research Ethics number (BUFVTM-1-1-2025) of Benha University's Faculty of Veterinary Medicine.

2.2. Sample collection

In a survey investigation, 15 samples of each camel and beef *longissimus thoracis* (*LTM*) muscle (10^{th}–13^{th} ribs) ribeye were randomly selected, irrespective of basic contributing characteristics including age, sex, and ration composition. Additionally, the current study used quantitative instrumental contemporary methods to assess ultimate muscle pH, purge loss, cooking loss percent, Warner-Bratzler shear force, and color to avoid variations that may arise from panel-based procedures, cultural differences, or preparation formats. The samples were collected from Tanta and Tukh cities

2.3. Physicochemical evaluation of longissimus attributes

The physicochemical characteristics of *LTM*-steaks, including pH, Drip loss, Cooking loss (CL), Warner-Bratzler Shear Force (WBSF), and color parameters (*L**, Lightness; *a**, Redness; *b**, Yellowness; *C*, Chroma; and *h*, Hue angle), were evaluated using related methodologies as fully described in our previously published papers (Dawam et al., 2024; Elsheikh et al., 2024).

2.3.1. pH analysis

The *LTM* samples selected for pH evaluation were each diluted ten times with sterile distilled water before being subjected to a pH-meter analysis utilizing electrodes (Jenway 3510 pH-meter, Cole-Parmer, Staffordshire, United Kingdom).

2.3.2. Purge loss estimation.

The 48-hour purge loss was calculated using the percentage of *LTM* steaks' weight loss from their initial weight on the first day of chilling (Honikel, 1998).

2.3.3 Cooking loss estimation

To assess the shear force and cooking loss, two samples were subsampled from the refrigerated *LTM*-steak replicates. Depending on the basis of the replication, shear force blocks were assigned at random to two cook batches. The pre-weighed *LTM* steaks were individually placed in thin-walled polypropylene thermotolerant bags and cooked in a ready-water bath at 80 °C for 30 minutes. After that, they were cooled to room temperature using tap water before being cooled to 5 °C in an ice bath, wiped dry, and weighed again. CL is the percentage difference between the raw and cooked weights (Honikel, 1998).

2.3.4. Warner-Bratzler Shear Force analysis

The 3343 Universal Test Device Mono column (Instron, Norwood, MA, USA) was used to test the Warner-Bratzler Shear Force (WBSF) on cooked *LTM* steaks. Cores from the anterior end of each *LTM* were sheared perpendicular to the fiber's direction. The WBSF value, expressed in kilogram-force (kgf), was the average measurement of six cores from each *LTM*-steak (American Meat Science Association, 2015).

2.3.5. Instrumental color estimation

In the raw *LTL*-steaks, three colors— *L**, *a**, and *b**—were quantified with the chromometer CR-410 (Konica Minolta Sensing INC., Osaka, Japan). Chroma Metre calibrated for the L*, a*, and b* color spaces, illuminant D65, observer angle of 2°, aperture size of 8.0 mm, and closed cone. A standardized white tile was used to calibrate the chromameter prior to measurement, and after the *LTL*-steak had blossomed for 30 minutes, measurements were taken over its cut surface. These color values were then used to determine color intensity ($C = (a^{*\wedge 2} + b^{*\wedge 2})^{\wedge 0.5}$) and color saturation (Hue angle (h°) = arctg b^*/a^*). For every group, six measurements were averaged. Increased saturation in the primary color of the sample is indicated by higher chroma values. Conversely, a lower amount of red meat is indicated by larger hue angle (or color intensity) values (American Meat Science Association, 2012).

2.4. Statistical analysis

SPSS Version 22 (SPSS Inc., Chicago, IL, USA) was used to analyze the data. The effects of species (camel and cattle) on physicochemical characteristics and CIE *L**, *a**, and *b** color values of *LTM* were examined using a one-way ANOVA. The species of the animals were regarded as fixed variables, whereas the *LTM* was regarded as random. The means and standard errors of the results are displayed. The statistical model compared meat quality attributes means using Tukey's b comparison tests. a P value of less than 0.05 was considered to indicate a significant difference. The correlation analysis of the physicochemical properties of beef and camel meat was conducted using the Scikit-learn library in Python 3.9. Scikit-learn provides efficient and reliable statistical tools for assessing relationships between variables, ensuring accurate evaluation of the associations within the dataset. This approach allowed for a comprehensive understanding of how different physicochemical attributes of beef and camel meat interact, aiding in data-driven insights and comparative analysis.

3. RESULTS

Camel *LTM* exhibited higher pH (6.42 vs. 6.17) and cooking loss (39.51% vs. 32.63%), but lower purge loss (3.61% vs. 5.24%) and WBSF (5.87 vs. 6.66) compared to beef muscle ($P < 0.05$) (Table 1).

Table 1 Physicochemical attributes of Camel *longissimus* muscle (*n*=15) compared to that of beef muscle (*n*=15).

Parameter	*Camel*				*Cattle*				*P value*
	Min	Max	Mean ±SE		Min	Max	Mean ±SE		
pH	5.54	7.00	6.42[a]	0.05	5.57	6.95	6.17[b]	0.04	0.0003
Purge loss	1.61	5.61	3.61[b]	0.30	1.37	9.41	5.24[a]	0.45	0.009
Cooking loss	32.58	43.46	39.51[a]	0.87	18.72	41.39	32.63[b]	1.28	0.0003
WBSF	3.34	9.27	5.87[b]	0.16	3.26	11.59	6.66[a]	0.26	0.015

According to the current data, the average *L** of camel meat was significantly lower than that of beef (P< 0.05), at 38.66 against 40.56. However, compared to beef, camel meat showed significantly greater levels of *a** (15.41 vs 12.66), *b** (7.86 vs 6.83), and chroma (17.34 vs 14.48) (P< 0.05) (Figure 1).

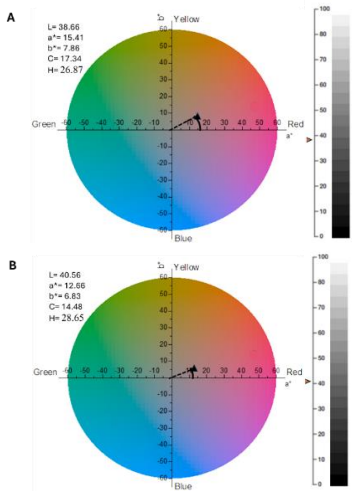

Figure 1: *a**−*b**, *C**−*H** and *L** graph for (A) Camel Meat and (B) Beef meat. In the *a**−*b** graph, the black triangle represents the point (*a**, *b**) of the meat samples. In the *C**−*H** graph, *C** is graphically the length of the dotted line, and *H** is represented as the angle. In the *L** graph, the red triangle represents the *L** value for meat samples. *L**, Lightness; *a**, Redness; *b**, Yellowness; *C*, Chroma; and *h*, Hue angle.

To illustrate the relationships between the variables (pH, Cooking Loss, Purge Loss, and WBSF) within each group (Beef and Camel), figure (2) showed potential correlations between variables by assessing the shading intensity for each group. The pH and cooking loss show relatively light shades, suggesting that there might be a weak or neutral correlation between pH and cooking loss for beef. While pH remained low, purge loss for beef shows a much higher value. This inverse relationship could imply that lower pH levels may contribute to increased purge loss due to reduced water retention in the meat. WBSF, which measures meat tenderness, showed similar lower values as pH and Cooking Loss. This indicated that the tenderness of beef does strongly align with pH and Cooking Loss.

4. DISCUSSION

This research focuses on physicochemical and color characteristics of camel versus cattle meat collected from Egyptian marketplaces, particularly Tanta and Toukh cities. According to the physicochemical characteristics of the current investigation, the *LTM* of the camel showed lower purging loss (3.61% vs. 5.24%) and WBSF (5.87 vs. 6.66), but higher pH (6.42 vs. 6.17) and cooking loss (39.51% vs. 32.63%) than the muscle of the beef (P<0.05). At six and twenty-four hours after slaughter, the pH values of camel meat were much higher than those of beef, and the pH values of younger animals' muscles were significantly higher than those of older animals (Eskandari et al., 2013).

In comparison to beef, studies consistently demonstrated that camel meat has a higher ultimate pH, a slower postmortem pH decline, a lower water-holding capacity, higher cooking losses, and greater collagen insolubility (Eskandari et al., 2013). These differences could be attributed to both extrinsic conditions (such as storage temperature and slaughter stress) and intrinsic factors (such as glycogen reserves and collagen properties) (Alamin, 2015; Hassanien et al., 2022; Manheem et al., 2023). Intrinsic factors like collagen properties and glycogen stores have a major impact on the pH and glycolysis of camel meat. More precisely, it has been noted that camel meat has a higher final pH (~5.8–6.2) and a longer pH decline than beef (~5.4–5.7) attributed to lower glycolytic enzyme activity and glycogen stores, which affect WHC and microbial stability (Alamin et al., 2015; Hassanien et al., 2022; Manheem et al., 2023).

The lower purge loss compared to beef may be explained by the higher final pH of camel meat, which may have improved WHC. Lower WHC and thermal stability are associated with heat-induced protein denaturation in camel meat, which causes greater cooking loss than beef when cooked using different techniques (roasting, braising, etc.) (Bahwan et al., 2023). Larger amounts of insoluble collagen are found in camel meat, especially in older animals, which accounts for higher shear force values (firmer texture) and higher cooking losses during shrinkage (Hassanien et al., 2022; Manheem et al., 2023). Contrary to the well-known fact that camel meat is tougher than beef (Kadim et al., 2009; Hassanien et al., 2022; Manheem et al., 2023), the camel *LTM* in the current study displayed lower WBSF (5.87 vs. 6.66) and purge loss (3.61% vs. 5.24%) than the muscle of the beef. Other previously published findings indicated that when slaughtered at a similar age range, the meat quality and composition of Arabian camel *LTM* is identical to that of Omani beef muscle (Kadim et al., 2008). Similarly, Alamin et al. (2015) indicated that shear force (4.60 and 5.11) and water holding capacity (WHC) (3.07 and 2.67) did not differ substantially (P> 0.05) between the beef and camel varieties. However, the differences in connective tissue strength between both meat kinds were statistically significant (P< 0.001). Therefore, the values of camel meat were greater than those of beef (3.57 and 2.62, respectively) (Alamin et al., 2015). This inconsistency is primarily due to the current survey's random sample collection criteria, which did not commit to a certain age and breed range.

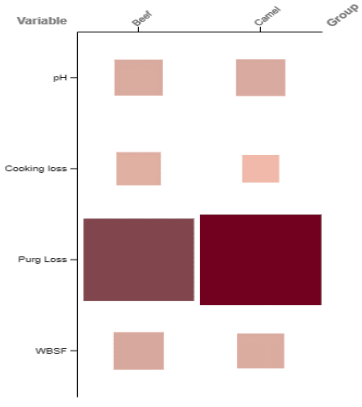

Figure 2 The relationship between different variables (pH, Cooking Loss, Purge Loss, and WBSF) within each group (Beef and Camel)

Furthermore, previous comparative studies did not standardize production variables like stress or the distinction between grain-fed and grass-fed cattle and camels, which limited the mechanistic clarity of the results.

Regarding extrinsic factors, such as slaughter stress, it was reported that camels have greater levels of cortisol before slaughter, especially when pre-slaughter care and slaughter practices were not followed properly (Eskandari et al., 2013; Suliman et al., 2019) This results in decreased glycogen stores, delayed pH drop, and abnormalities in WHC and cooking losses (Eskandari et al., 2013; Suliman et al., 2019). Extrinsic factors such as temperature may have also contributed to the current results' disagreements with previous findings. Although cold storage (≤4°C) helps reduce purge losses in beef, camel meat has higher drip loss and faster lipid degradation during refrigerated storage (Kadim et al., 2008; Si et al., 2022; Lyu et al., 2024). The significant influence of season on camel muscle color, final pH (pHu), and chemical composition further confirmed the temperature effect (Abdelhadi et al., 2012).

One important quality factor that affects consumer purchasing decisions and freshness perceptions is meat color (de Araújo et al., 2022). Because of particular physiological, metabolic, and environmental aspects, camel meat differs significantly from beef in color dynamics. These variations result from the interaction of extrinsic factors like packaging, storage conditions, slaughter stress, and environmental impacts with intrinsic factors including myoglobin content, muscle fiber composition, and postmortem pH behavior. Camel meat had a considerably lower L^* average (38.66 vs 40.56) compared to beef ($P < 0.05$). Nonetheless, camel meat had considerably higher levels of a^* (15.41 vs 12.66), b^* (7.86 vs 6.83), and chroma (17.34 vs 14.48) than beef, suggesting that camel flesh was redder but less brilliant. This conclusion is supported by lower h° (26.87 vs. 28.65) values of camel meat compared t o beef, even if they were not significant.

Conversely, Alamin et al. (2015) indicated that beef had higher lightness, redness, and yellowness values, while camel meat appeared darker and redder overall. Meat from camels has higher levels of myoglobin, the main pigment that gives muscle tissue its red hue, than beef. A darker, brownish-red look than the brighter red hues usually found in fresh beef is the result of this higher concentration combined with camel meat's dependence on oxidative metabolism because of the species' adaption to arid conditions (Kadim et al., 2008; Manheem et al., 2023). The processes and mechanisms of myoglobin oxidation are essential for maintaining color stability. Myoglobin oxidizes from the bright red oxy-myoglobin state to the brown metmyoglobin state during storage, and this change occurs more quickly in camel meat due to variations in pH, lipid oxidation rates, and oxidative muscle metabolism (Kadim et al., 2009; Manheem et al., 2023). Regarding the effect of muscle fiber composition, slow-twitch oxidative (Type I) muscle fibers, which are abundant in myoglobin and mitochondria, make up most of camel meat. These fibers give camel meat its deeper *hue* since they are made to withstand dry and resource-poor environments. Beef, on the other hand, typically has a more equal makeup of slow-twitch (Type I) and fast-twitch (Type II) fibers, which helps explain its generally brighter color and variations in the characteristics of muscle metabolism (Kadim et al., 2009; Lyu et al., 2024). Nonetheless, the higher ultimate pH of camel meat than that of beef (5.5-5.7) is associated with greater water-holding capacity (WHC), increased opacity, and decreased color brightness, leading to the darker appearance of camel meat (Kadim et al., 2008; Soltanizadeh et al., 2008; Alamin, 2015). Additionally, camel meat is more prone to lipid peroxidation than beef due to its somewhat higher iron content and polyunsaturated fatty acids (PUFAs). Iron can catalyze oxidative reactions that promote myoglobin oxidation, which causes metmyoglobin to form faster and discolor earlier (Jouki and Khazaei, 2012; Hassanien et al., 2022; Manheem et al., 2023).

Extrinsic factors, such as storage temperature and pre-slaughter stress, influence the color stability of camel meat. Several researchers (Jouki and Khazaei, 2012; Hassanien et al., 2022) suggested that camel meat had lower color stability than beef under refrigeration due to rapid lipid oxidation. Camels frequently undergo heightened pre-slaughter stress and elevated stress hormones like cortisol, which deplete muscle glycogen stores and increase pH, contributing to darker meat (with qualities similar to dark, firm, and dry [DFD] meat in other species) (Abdelilah Lemrhamed et al., 2019).

5. CONCLUSIONS

Current research findings confirm that camel meat is permanently associated with higher pH, cooking loss, and darker red meat, and hence is unaffected by fundamental contributing factors. The fluctuation and interactions of these components, however, have a significant impact on purge loss and camel meat tenderness. Future marketing initiatives may therefore concentrate on tenderness and purge loss to increase customer acceptability of camel meat as a possible red meat substitute.

6. REFERENCES

1. Abdelhadi, O.M.A., Babiker, S.A., Picard, B., Jurie, C., Jailler, R., Hocquette, J.F., Faye, B., 2012. Effect of season on contractile and metabolic properties of desert camel muscle (Camelus dromedarius). Meat Science 90, 139–144. https://doi.org/10.1016/j.meatsci.2011.06.012
2. Abdelilah Lemrhamed, R.T., Abbadi, N.E., Belhouari, A., Faye, B., Khasmi, M.E., 2019. Relationship between circulating levels of cortisol at slaughter and changes of some parameters of the camel meat during ageing. Emirates Journal of Food and Agriculture 874. https://doi.org/10.9755/ ejfa.2019.v31.i11.2031
3. Alamin, S.A., 2015. Sensory Evaluations of Different Types of Red meat in Sudan. Bull. Env. Pharmacol. Life Sci., 4(11): 45-48
4. Alamin, S.A., Elshafia, S.A., Ahmed, D.A., 2015. Study in some quality attribute of meat. International Journal of Scientific & Technology Research 4, 42–44.
5. American Meat Science Association, 2015. Research guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of meat. Champaign, IL, USA: American Meat Science Association.
6. American Meat Science Association, 2012. AMSA Meat Color Measurement Guidelines: AMSA. American Meat Science Association.
7. Ashour, G., Abdel-Rahman, S.M., 2022. Camels as a miracle key for animal production sustainability in Egypt. Egyptian Journal of Animal Production 59, 33–43. https://doi.org/ 10.21608/ ejap.2022.244947
8. Baba, W.N., Rasool, N., Selvamuthukumara, M., Maqsood, S., 2021. A review on nutritional composition, health benefits, and technological interventions for improving consumer acceptability of camel meat: an ethnic food of Middle East. Journal of Ethnic Foods 8. https://doi.org/10.1186/s42779-021-00089-1
9. Bahwan, M., Baba, W.N., Adiamo, O., Hassan, H.M., Roobab, U., Abayomi, O.O., Maqsood, S., 2023. Exploring the impact of various cooking techniques on the physicochemical and quality characteristics of camel meat product. Animal bioscience 36, 1747.

10. Chiang, J.H., Tay, W., Ong, D.S.M., Liebl, D., Ng, C.P., Henry, C.J., 2021. Physicochemical, textural and structural characteristics of wheat gluten-soy protein composited meat analogues prepared with the mechanical elongation method. Food Structure 28, 100183.
11. Dawam, W., Edris, S., Osman, A., Elsheikh, M., Hamad, A., Sitohy, M., Sabeq, I., 2024. Cowpea legumin preservative impacts on beef ribeye and implications on antibiotic resistant food borne pathogens. NPI Science of Food 8, 96. https://doi.org/10.1038/s41538-024-00337-z
12. de Araújo, P.D., Araújo, W.M.C., Patarata, L., Fraqueza, M.J., 2022. Understanding the main factors that influence consumer quality perception and attitude towards meat and processed meat products. Meat Science 193, 108952. https://doi.org/10.1016/j.meatsci.2022.108952
13. Elsheikh, M., Dawam, W., Edris, S., Osman, A., Sitohy, M., Sabike, I.I., 2024. Cowpea 11S globulin spray quadruples shrimp shelf-life and maintains freshness. Benha Veterinary Medical Journal 46, 74–79.
14. Eskandari, M.H., Majlesi, M., Gheisari, H.R., Farahnaky, A., Khaksar, Z., 2013. Comparison of some physicochemical properties and toughness of camel meat and beef. Journal of Applied Animal Research 41, 442–447. https://doi.org/10.1080/09712119.2013.792735
15. Hassanien, M., El-Khateib, T., Hassan, M., Abd-El-Malek, A., 2022. Changes in camel and cattle meat during chilling preservation. Assiut Veterinary Medical Journal 68, 1–9. https://doi.org/10.21608/avmj.2022.114286.1048
16. Honikel, K., 1998. Reference methods for the assessment of physical characteristics of meat. Meat Science 49, 447–457. https://doi.org/10.1016/s0309-1740(98)00034-5
17. Jouki, M., Khazaei, N., 2012. Color and oxidation changes in camel meat during storage. International Journal of Pharma and Bio Sciences 3.
18. Kadim, I., Mahgoub, O., Purchas, R., 2008. A review of the growth, and of the carcass and meat quality characteristics of the one-humped camel (*Camelus dromedaries*). Meat Science 80, 555–569.
19. Kadim, I.T., Mahgoub, O., 2008. Effect of age on quality and composition of one-humped camel longissimus muscle. International Journal of Postharvest Technology and Innovation 1, 327–336.
20. Kadim, I.T., Mahgoub, O., Al-Marzooqi, W., 2008. Meat quality and composition of Longissimus thoracis from Arabian camel (Camelus dromedaries) and Omani beef: A comparative study. J. Camelid Sci 1, 37–47.
21. Kadim, I.T., Mahgoub, O., Al-Marzooqi, W., Khalaf, S.K., Mansour, M.H., Al-Sinani, S.S.H., Al-Amri, I.S., 2009. Effects of electrical stimulation on histochemical muscle fiber staining, quality, and composition of camel and cattle longissimus thoracis muscles. Journal of Food Science 74. https://doi.org/10.1111/j.1750-3841.2008.00992.x
22. Kadim, I.T., Mahgoub, O., Faye, B., Farouk, M.M., 2013. Camel meat and meat products. CABI. Pp. 35-60.
23. Kandil, H., Wassif, I.M., Rabee, A., Shokry, M.M., Khidr., R.E.S., Askar, A.R., 2023. Camel, the animal of food security and climate change. Egyptian Journal of Camel Science 1, 1–8. https://doi.org/10.21608/ejcs.2023.220447.1008
24. Li, Q., Yang, L., Li, R., Chen, G., Dong, J., Wu, L., Fu, Y., Yang, J., 2023. Lipid analysis of meat from Bactrian camel (Camelus bacterianus), beef, and tails of fat-tailed sheep using UPLC-Q-TOF/MS based lipidomics. Frontiers in Nutrition 10.
25. Liu, J., Ellies-Oury, M.-P., Stoyanchev, T., Hocquette, J.-F., 2022. Consumer perception of beef quality and how to control, improve and predict it? Focus on eating quality. Foods 11. https://doi.org/10.3390/foods11121732
26. Lyu, H., Na, Q., Wang, L., Li, Yafei, Zheng, Z., Wu, Y., Li, Yuanyuan, Hang, G., Zhu, X., Ji, R., Guo, F., Ming, L., 2024. Effects of muscle type and aging on glycolysis and physicochemical quality properties of bactrian camel (Camelus bactrianus) meat. Animals (Basel) 14, 611. https://doi.org/10.3390/ani14040611
27. Manheem, K., Adiamo, O., Roobab, U., Mohteshamuddin, K., Hassan, H.M., Nirmal, N., Maqsood, S., 2023. A comparative study on changes in protein, lipid and meat-quality attributes of camel meat, beef and sheep meat (mutton) during refrigerated storage. Animals 13. https://doi.org/10.3390/ani13050904
28. Mohamed, M.-Y.I., Lakshmi, G.B., Sodagari, H., Habib, I., 2024. A One Health perspective on camel meat hygiene and zoonoses: Insights from a decade of research in the Middle East. Veterinary Sciences 11. https://doi.org/10.3390/vetsci11080344
29. Nasrabadi, M.N., Doost, A.S., Mezzenga, R., 2021. Modification approaches of plant-based proteins to improve their techno-functionality and use in food products. Food Hydrocolloids 118, 106789.
30. Raiymbek, G., Kadim, I., Konuspayeva, G., Mahgoub, O., Serikbayeva, A., Faye, B., 2015. Discriminant amino-acid components of Bactrian (Camelus bactrianus) and Dromedary (Camelus dromedarius) meat. Journal of Food composition and analysis 41, 194–200.
31. Reza Gheisari, H., Aminlari, M., Shahram Shekarforoush, S., 2009. A comparative study of the biochemical and functional properties of camel and cattle meat during frozen storage. Veterinarski arhiv 79, 51–68.
32. Santos, D., Monteiro, M.J., Voss, H.-P., Komora, N., Teixeira, P., Pintado, M., 2021. The most important attributes of beef sensory quality and production variables that can affect it: A review. Livestock Science 250, 104573. https://doi.org/10.1016/j.livsci.2021.104573
33. 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, 1021. https://doi.org/10.3390/foods11071021
34. Soltanizadeh, N., Kadivar, M., Keramat, J., Fazilati, M., 2008. Comparison of fresh beef and camel meat proteolysis during cold storage. Meat Science 80, 892–895. https://doi.org/10.1016/j.meatsci.2008.04.007
35. Suliman, G.M., Alowaimer, A.N., Hussein, E.O.S., Ali, H.S., Abdelnour, S.A., El-Hack, M.E.A., Swelum, A.A., 2019. Chemical composition and quality characteristics of meat in three one-humped camel (Camelus dromedarius) breeds as affected by muscle type and post-mortem storage period. Animals (Basel) 9, 834. https://doi.org/10.3390/ani9100834.