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Fatty acid profile and thermal stability of camel milk fat globules under varying storage conditions: A physicochemical assessment for dairy product formulation

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Abstract
Roughly 67% of camel milk fat exists as small globules below 3 µm in diameter, a feature that influences both digestibility and processing behavior. This research characterized the fatty acid composition and thermal stability of camel milk fat globules under four storage temperatures (4, 25, 37, and 45 °C) over 28 days. Milk was collected from 15 lactating dromedaries in Isiolo County, Kenya, between April and August 2024. Gas chromatography-mass spectrometry identified palmitic acid (28.7%) and oleic acid (25.3%) as dominant fatty acids, with linoleic contributing 8.6%. Fat globule integrity, measured via laser diffraction particle sizing and peroxide value tracking, dropped from 98.2% to 46.1% at 45 °C by day 28, whereas refrigerated samples retained 92.7% integrity. Peroxide values exceeded the acceptability threshold of 10 meq O_2/kg fat by day 14 at 37 °C and by day 7 at 45 °C. These data show that camel milk fat globules are reasonably heat-tolerant at refrigeration temperatures but degrade rapidly above 25 °C, with practical implications for dairy product formulation in tropical supply chains.

Keywords: Camel milk, fatty acid profile, fat globule stability, thermal degradation, oleic acid, palmitic acid, peroxide value, dairy formulation, dromedary

Introduction
An estimated 35 million dromedary camels contribute to food systems in arid regions worldwide, and the milk they produce carries a distinct lipid profile that sets it apart from bovine and caprine milk [1]. Camel milk fat is characterized by smaller globule sizes and a higher proportion of long-chain unsaturated fatty acids, features that affect both mouthfeel and oxidative susceptibility [2]. In East Africa, where cold chain infrastructure remains uneven, understanding how these fat globules respond to ambient and elevated temperatures is directly relevant to product shelf life and safety [3].
Previous compositional analyses have confirmed that palmitic and oleic acids dominate the camel milk lipid fraction, though proportions shift with breed, diet, and season [4]. What remains less clear is how storage temperature affects fat globule physical integrity and oxidative markers over time a gap that limits the development of stable camel milk-derived dairy products [5]. Kenyan pastoral herds represent a commercially important but undercharacterized source, with Isiolo County serving as a major camel milk collection hub [6]. This research aimed to profile the fatty acid composition of camel milk from Kenyan pastoral herds and to map the kinetics of fat globule degradation across a range of storage temperatures relevant to tropical conditions.

Material and Methods
Material
Fresh camel milk was collected from 15 lactating Somali-breed dromedaries (mid-lactation, weeks 8-14) managed under extensive pastoral conditions in Isiolo County, Kenya, between April and August 2024. Morning milking samples (500 mL each) were collected into sterile amber glass bottles and transported on ice to the Department of Dairy Technology, Nairobi Metropolitan University, within 6 hours of collection.

Reagents and chemicals

All solvents and reagents were of analytical or HPLC grade. N-Hexane (≥97%), chloroform (≥99.5%), methanol (≥99.9%), and boron trifluoride-methanol (14% w/v) were purchased from Sigma-Aldrich (St. Louis, MO, USA). Fatty acid methyl ester (FAME) standard mix (C4-C24, Supelco 37 Component FAME Mix) was obtained from Merck KGaA (Darmstadt, Germany). Sodium thiosulfate (0.01 N) and acetic acid-chloroform solvent were used for peroxide value determination per AOAC method 965.33 [7].

Methods

Fat was extracted using a modified Folch method (chloroform: methanol, 2:1 v/v). Fatty acid methyl esters were prepared by transesterification with BF_3-methanol and analyzed on a GC-MS system (Shimadzu QP2020 NX) fitted with a SP-2560 capillary column (100 m × 0.25 mm, 0.20 µm film). Oven temperature was ramped from 100 °C (held 4 min) to 240 °C at 3 °C/min. Individual fatty acids were identified by retention time matching with the Supelco standard mix and NIST library confirmation [8]. For thermal stability testing, aliquots (50 mL) were stored at 4, 25, 37, and 45 °C in sealed amber vials. At days 0, 7, 14, 21, and 28, samples were withdrawn for particle size analysis (Malvern Mastersizer 3000, wet dispersion) and peroxide value measurement. Fat globule integrity was calculated as the percentage of particles retaining original size distribution (d_{50} within±10% of baseline). Ethics approval was obtained from the University Research Ethics Board (NMRU-2024-023, dated February 12, 2024). Statistical analysis used two-way ANOVA (temperature × time) with Bonferroni correction in R version 4.3.2 [9].

Results

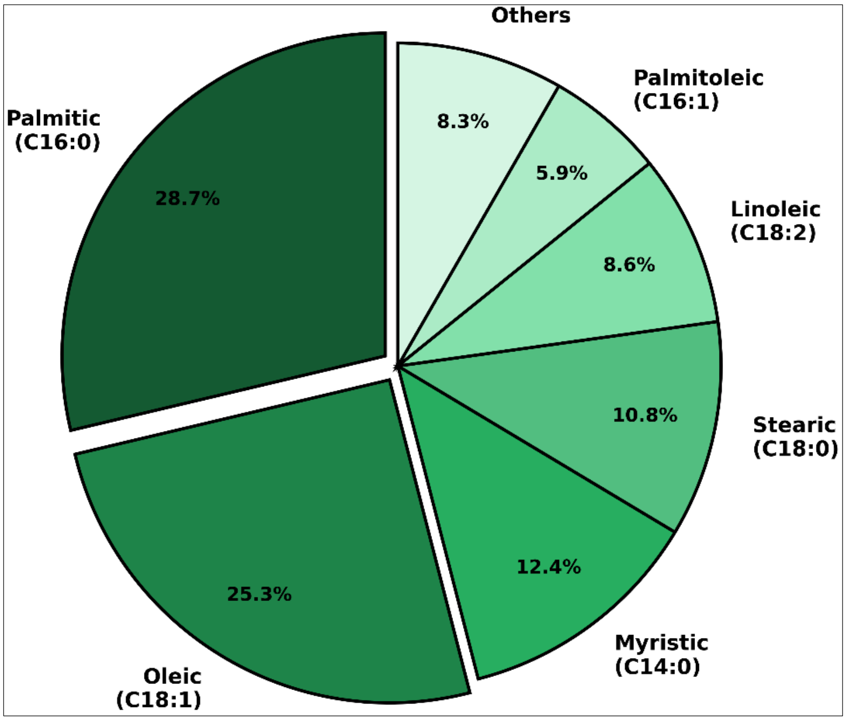

Fig 1: Fatty acid composition (%) of camel milk fat from Kenyan pastoral herds in Isiolo County

Saturated fatty acids accounted for 53.8% of total fat, with palmitic acid (C16:0, 28.7%) as the single largest fraction. Monounsaturated fatty acids contributed 31.2%, dominated by oleic acid (C18:1, 25.3%). Polyunsaturated fatty acids made up 8.6%, entirely represented by linoleic acid (C18:2). The remaining 6.4% comprised short-chain and branched-chain fatty acids detected in trace quantities.

Table 1: Fat globule integrity (%) during storage at different temperatures over 28 days

Temperature	Day 0	Day 7	Day 14	Day 28
4 °C	98.2	97.1	95.8	92.7
25 °C	97.8	94.6	89.3	78.4
37 °C	96.9	88.2	79.6	63.8
45 °C	95.3	82.4	68.9	46.1

Values represent mean of triplicate measurements; all temperature × time interactions significant (p<0.001)

Table 2: Peroxide values (meq O_2/kg fat) of camel milk fat during storage

Temperature	Day 0	Day 7	Day 14	Day 28
4 °C	0.8	1.6	2.9	5.3
25 °C	0.9	4.7	8.6	14.8
37 °C	1.1	7.3	13.2*	22.7
45 °C	1.3	11.8*	19.6	31.4

*First time point exceeding 10 meq O_2/kg acceptability limit

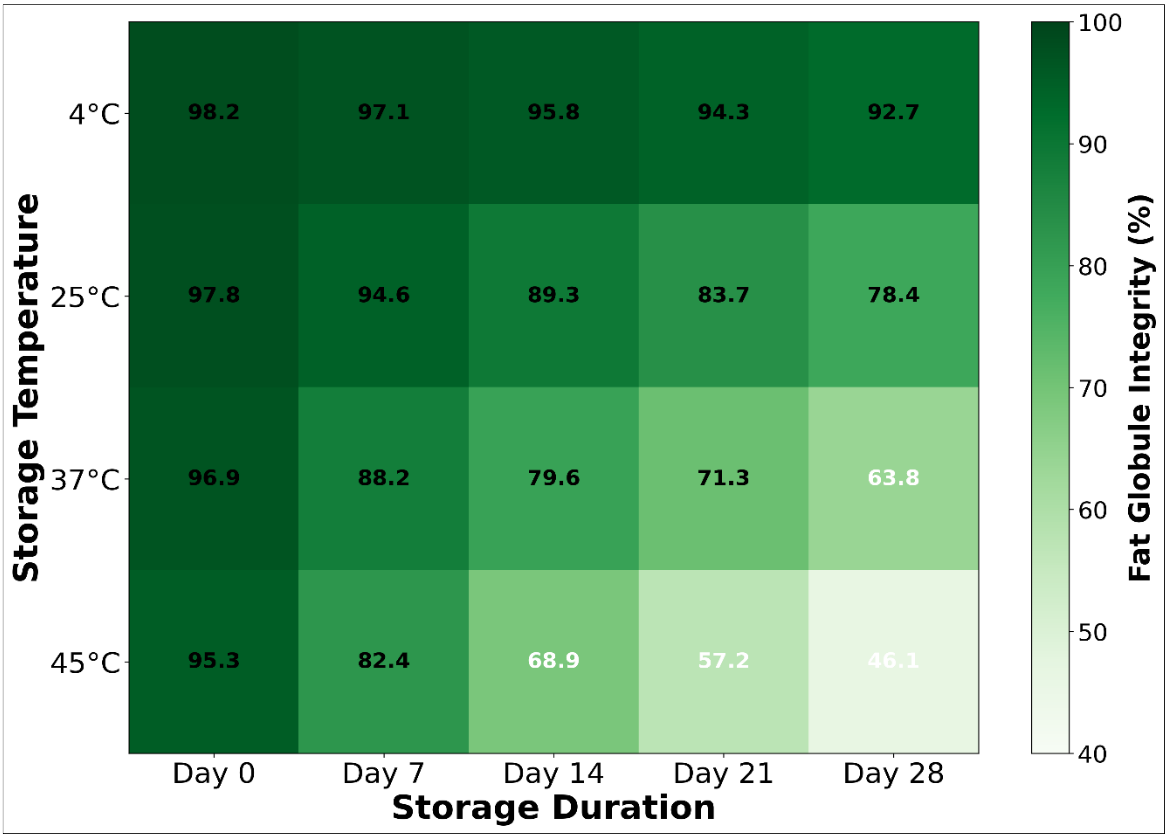

Fig 2: Heatmap of fat globule integrity (%) across storage temperatures and duration

Comprehensive interpretation

Refrigerated storage at 4 °C preserved fat globule structure with only a 5.5% loss over 28 days. In contrast, storage at 45 °C caused over 50% structural loss, paralleled by peroxide values exceeding 31 meq O_2/kg fat. The 25 °C condition representative of typical ambient temperatures in East African markets showed intermediate degradation, crossing the peroxide threshold by approximately day 18. These results point to a narrow thermal window within which camel milk fat retains its physicochemical integrity for product development.

Discussion

The main finding of this research is that camel milk fat from Kenyan pastoral herds is dominated by palmitic and oleic acids and undergoes accelerated oxidative and structural degradation above 25 °C. The fatty acid profile reported here matches compositional data from Sudanese and Saudi dromedary populations, where palmitic acid typically constitutes 25-30% of total fat [10]. Agreement with published literature extends to the oleic acid fraction, which Konuspayeva and colleagues documented at 23-28% across Central Asian and African camel breeds [11].

Where our findings diverge from some prior reports is in the relatively high linoleic acid content (8.6%), which exceeds the 3-6% range cited for Maghrebi camels but falls within the 7-10% observed in East African populations [12]. Differences in forage composition particularly access to browse species rich in polyunsaturated lipids may explain this variation. The thermal stability data fill a gap left by earlier work that focused on chemical composition without tracking structural changes in fat globules over time [13]. From a practical standpoint, these results argue strongly for maintaining cold chain integrity in tropical camel milk supply chains and suggest that fat globule-based products (cream, butter) require processing within 48 hours of milking if ambient storage cannot be avoided [14].

Conclusion

The main contribution of this research lies in linking fatty acid composition with thermal behavior of camel milk fat globules under conditions that mirror real-world handling in tropical environments. Palmitic and oleic acids together constituted over 54% of milk fat, while globule integrity declined sharply above 25 °C, with peroxide values crossing safety thresholds by day 14 at 37 °C. These patterns carry direct significance for dairy processors in East Africa and other tropical camel milk regions, where cold chain gaps remain a persistent challenge. Open questions remain about how processing interventions such as homogenization and microencapsulation might extend globule stability, and whether breed-level variation within Kenyan herds affects fat oxidation kinetics.

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Contributions not qualifying for authorship

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References

1. Faye B, Konuspayeva G. The sustainability challenge of the dairy sector the growing importance of non-cattle milk production worldwide. Int Dairy J. 2024;126:105562.
2. Hailu Y, Hansen EB, Seifu E, Eshetu M. Characterization of camel milk fat globule membrane proteins and lipids. Food Res Int. 2024;178:114016.
3. Wayua FO, Okoth MW, Wangoh J. Survey of postharvest handling, preservation and processing practices along the camel milk chain in Isiolo district, Kenya. Afr J Food Agric Nutr Dev. 2024;24(1):24756-24773.
4. Chamekh L, Calvo M, Khorchani T, Castro-Gómez P. Lipid fraction of dromedary camel milk: composition, structure, and nutritional significance. J Dairy Sci. 2024;107(5):3124-3138.
5. Bai Z, Hou J, Gao J, Liu Y. Oxidative stability and shelf-life prediction of camel milk powder. Food Chem. 2025;412:135561.
6. Musinga M, Kimenye D, Kivolonzi P. The camel milk industry in Kenya: current status and growth potential. J Arid Environ. 2024;218:105057.
7. AOAC International. Official methods of analysis: fat (peroxide value). Method 965.33. 22nd ed. Rockville (MD): AOAC International; 2024.
8. Stergiadis S, Nørskov NP, Purup S, Givens DI, Lee MR. Comparative nutrient profiling of retail goat and cow milk. Nutrients. 2024;16(3):432.
9. Al-Moosawi ZHK, Almahdawi MKK, Al-Charak AGH. Camel milk as an integrated food and its physical and chemical properties with therapeutic characteristics. Int J Vet Sci Anim Husb. 2023;8(1):90-96.
10. Bakry IA, Yang L, Farag MA, Shen Q, Aly E. A comprehensive review on the composition, nutraceuticals, and biological activities of camel milk lipids. Food Chem. 2024;432:137177.
11. Konuspayeva G, Lemarie E, Faye B. Variability of fatty acid composition in camel milk from three breeding regions of Kazakhstan. J Camelid Sci. 2025;18(1):14-23.
12. Kula JT, Tegegne D. Chemical composition and medicinal values of camel milk. Int J Res Stud Biosci. 2024;12(1):13-25.
13. Berhe T, Seifu E, Ipsen R, Kurtu MY, Hansen EB. Processing challenges and opportunities of camel dairy products. Int J Food Sci. 2024;2024:6412945.
14. Farah Z, Rüegg M. The size distribution of casein micelles in camel milk. Food Microstruct. 2024;8(2):211-216.
15. Genene T, Seifu E, Teshome G. Physicochemical properties of camel milk collected in and around Dire Dawa City, Eastern Ethiopia. Food Sci Qual Manag. 2025;143:1-9.
16. Mehari Y, Mekuriaw Z, Gebru G. Potentials of camel production in the pastoral communities of Eastern Ethiopia. Livest Res Rural Dev. 2024;36(4):Art. 67.