10th Dubai International Food Safety Conference (DIFSC)

Camel Milk – The Product of the 21st Century:
Food Safety, Quality and International Trade Requirements

Factors influencing the composition of camel milk and its suitability for use as a raw material in the manufacture of probiotic cultured dairy foods

László VARGA*,

Judit SÜLE*, Zsófia Nóra FÁBRI*, Judit JUHÁSZ†, Péter NAGY†

* *University of West Hungary, Mosonmagyaróvár, Hungary*

† *Emirates Industries for Camel Milk and Products, Dubai, UAE*

Global milk production
(*IDF, 2011*)

721 billion kg in 2010 (100-105 kg/person):

- 83% cow milk
- 13% buffalo milk
- 2.2% goat milk
- 1.3% sheep milk
- **0.3% camel milk**
- 0.2% other species' milk

Objectives

- Physicochemical and microbiological **quality of raw milk** influences its **processing characteristics**

- Aims of this research:
  - to monitor the microbial and chemical **composition of raw camel milk** produced by EICMP
  - to test the suitability of camel milk for use in the production of **probiotic fermented milks**

1. Microbiological quality of camel milk

(Nagy et al., 2013)

Monitoring of raw camel milk quality at EICMP

- Determination of microbiological parameters: since **2006**
- Monitoring of chemical composition: since **2009**
- Bulk milk samples taken **twice a day** (following the milking sessions)
- No. of lactating camels: 186–458
- Duration of microbiological study: **2008** and **2009** (January 2008 – January 2010)

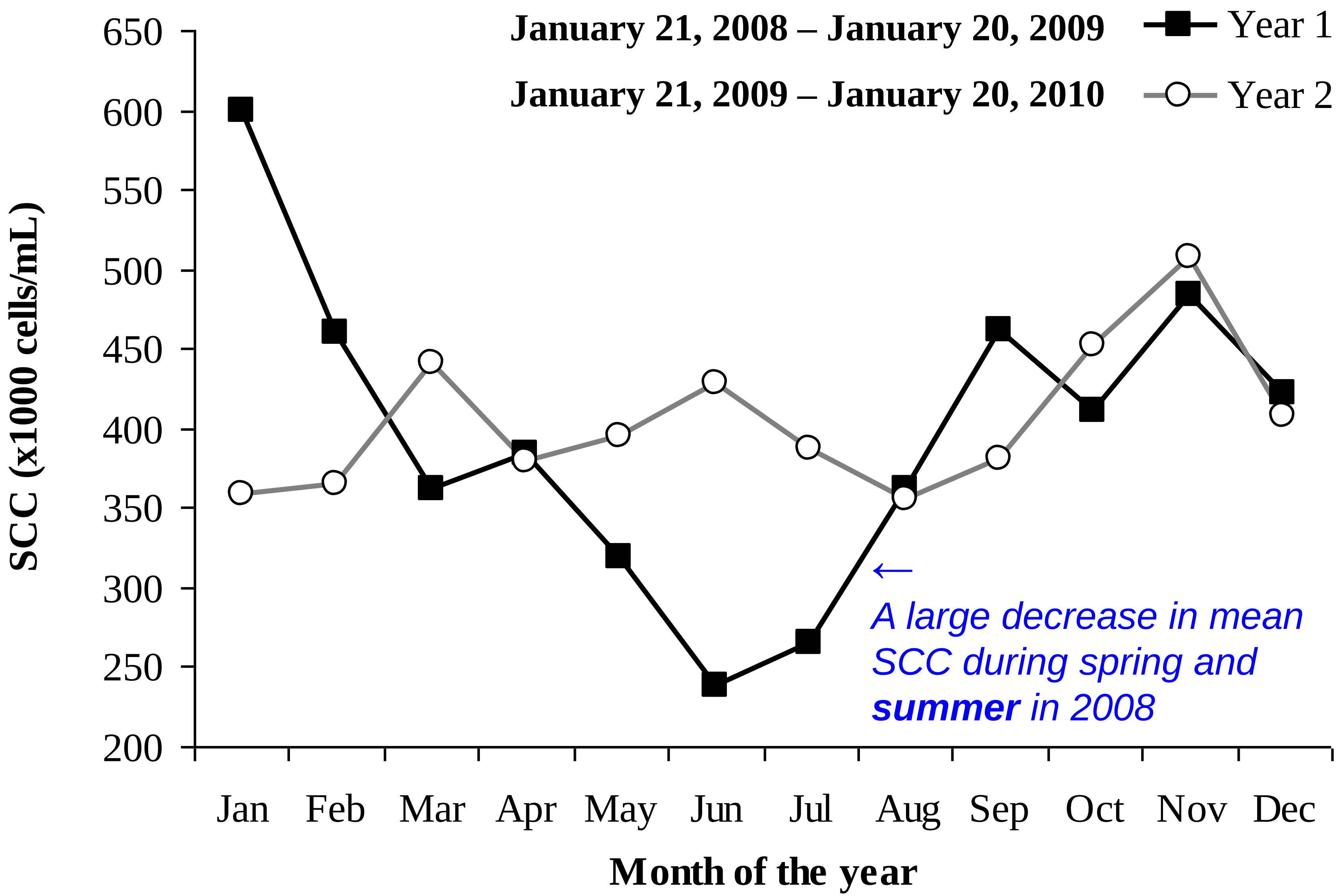


Figure 1: **Monthly variation in mean SCC in bulk camel milk according to the year of monitoring (*Nagy et al., 2013*)**

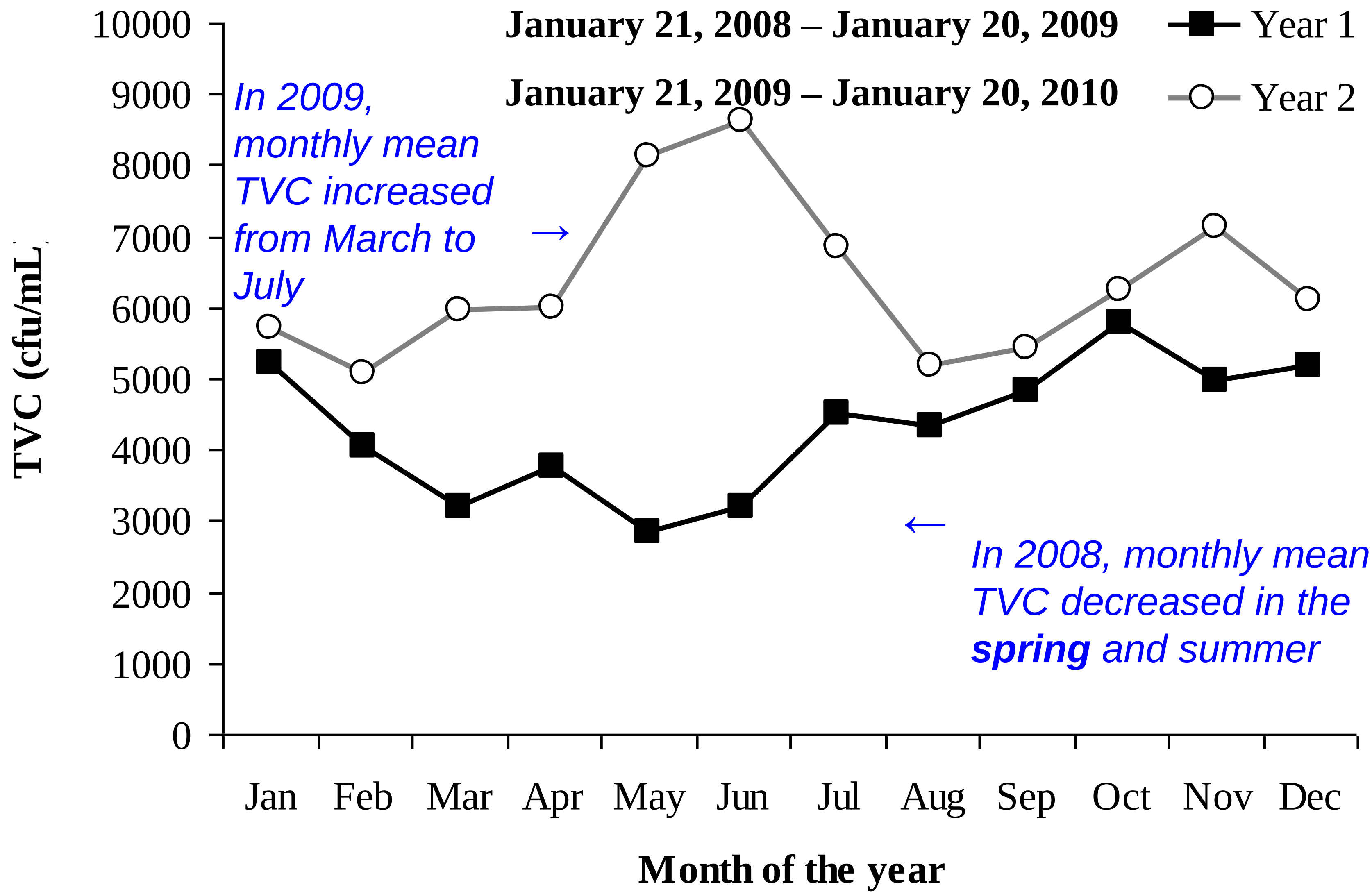


Figure 2: **Monthly variation in mean TVC in bulk camel milk according to the year of monitoring (*Nagy et al., 2013*)**

Mean SCC and TVC of camel milk at EICMP

- SCC = **394,000 cells/mL**
- TVC = **5,157 cfu/mL** (**excellent**)

Nagy et al. (2013)

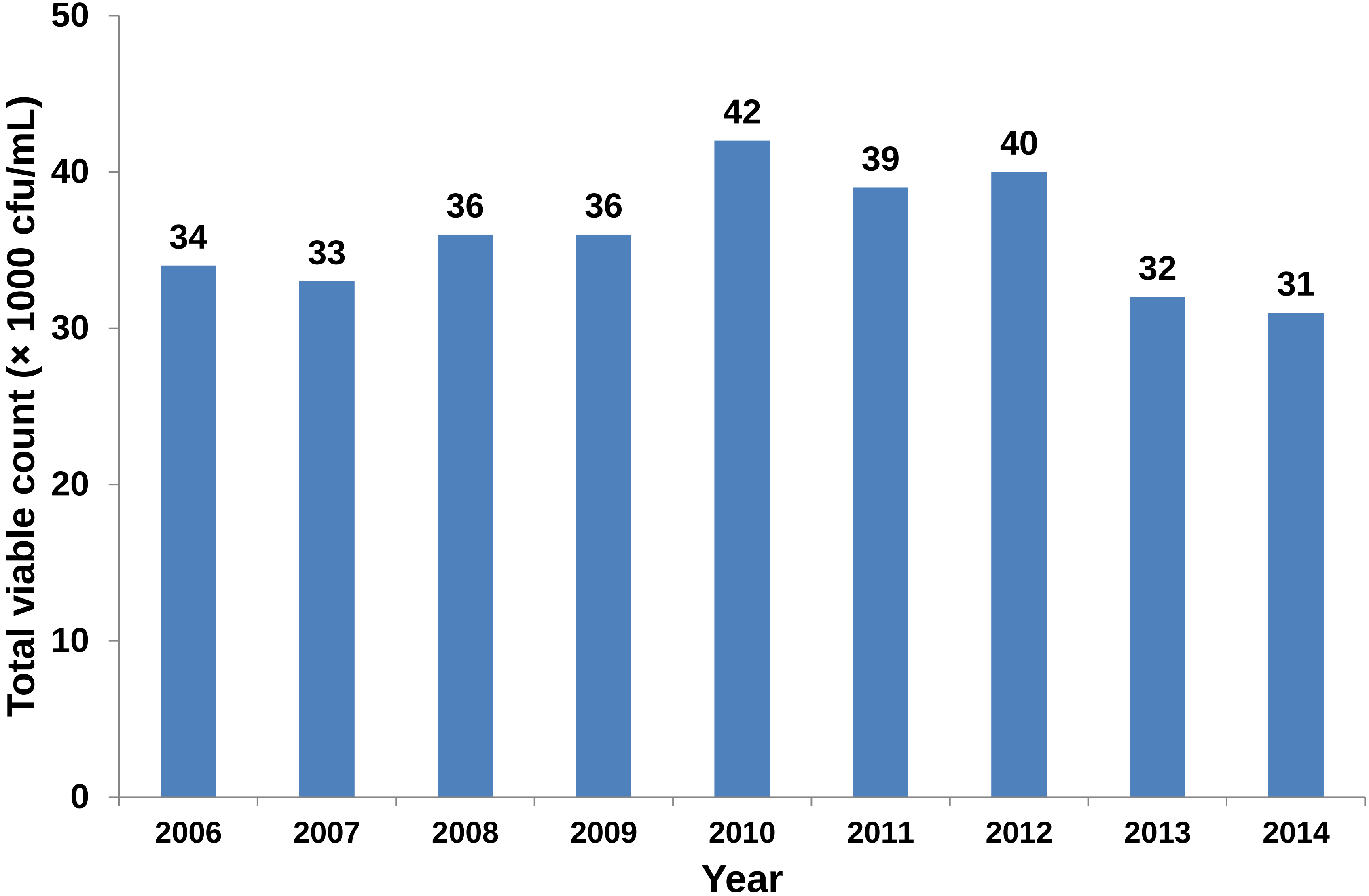
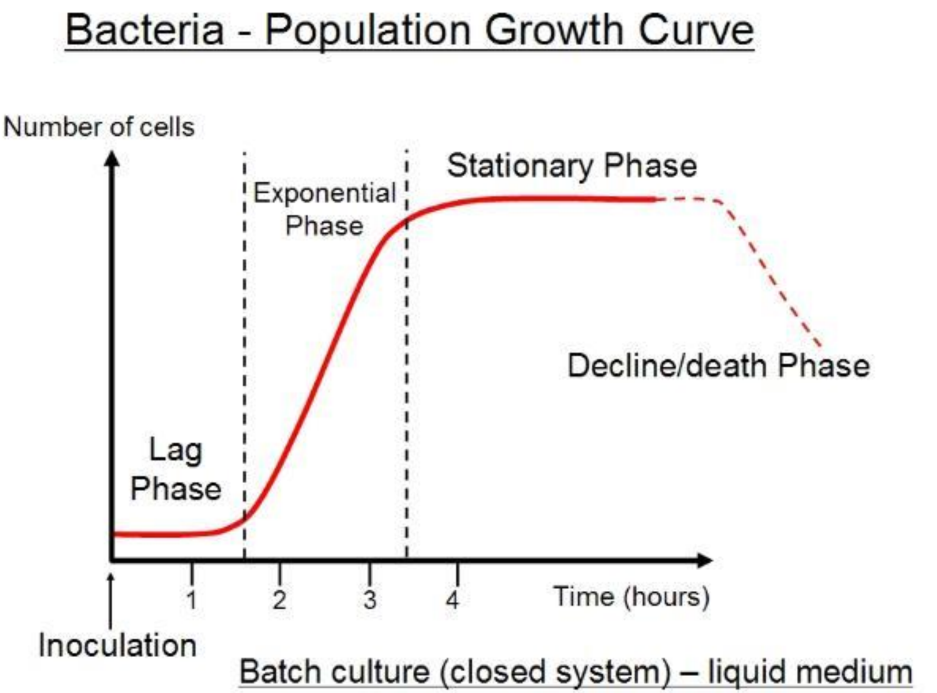


Figure 3: **Annual weighted mean TVC (× 1000 cfu/mL) in bulk cow milk in Hungary**

Growth potential of bacteria (a simple calculation)

- t_g = 20 min
- No. of bacteria following 48 h of growth: 2^{144} (**2.2×10^{43}**)
- Weight of one cell: 1.1×10^{-12} g
- Total weight of bacteria after 48 h: **2.5×10^{28} kg**
- Weight of Earth: **6.0×10^{24} kg**



https://www.premedhq.com/exponential-growth

- Weight of bacterial mass following 48 h of unlimited growth under optimum conditions: **4000 ×** weight of planet Earth

Cooperation between UWH and EICMP

- Regular discussions (Budapest, Mosonmagyaróvár, Dubai)
- Supervision of a **PhD student** (Ms. Zs. N. Fábri)
- Scientific **publications** (2 × *JDS*, 2 × *MÁL*, 2 × MS in preparation)
- **Presentations** at scientific conferences (ÓTN, Mosonmagyaróvár, Hungary; DIFSC 2015, Dubai, UAE)

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- Research project(s) hopefully funded by EU…

2. Chemical composition of camel milk

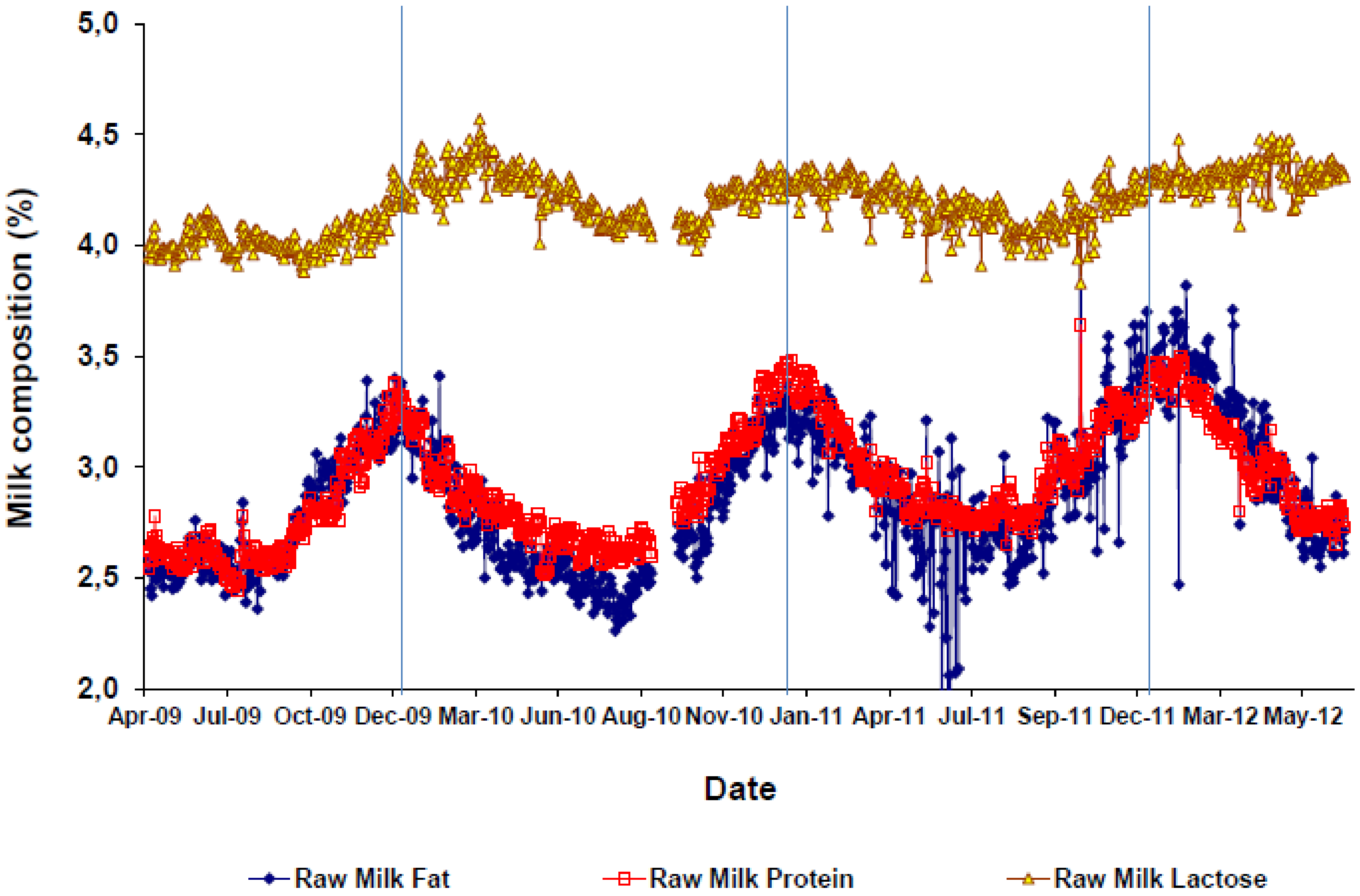

Figure 4: **Changes in fat, protein and lactose contents of raw camel milk between April 2009 and May 2012**

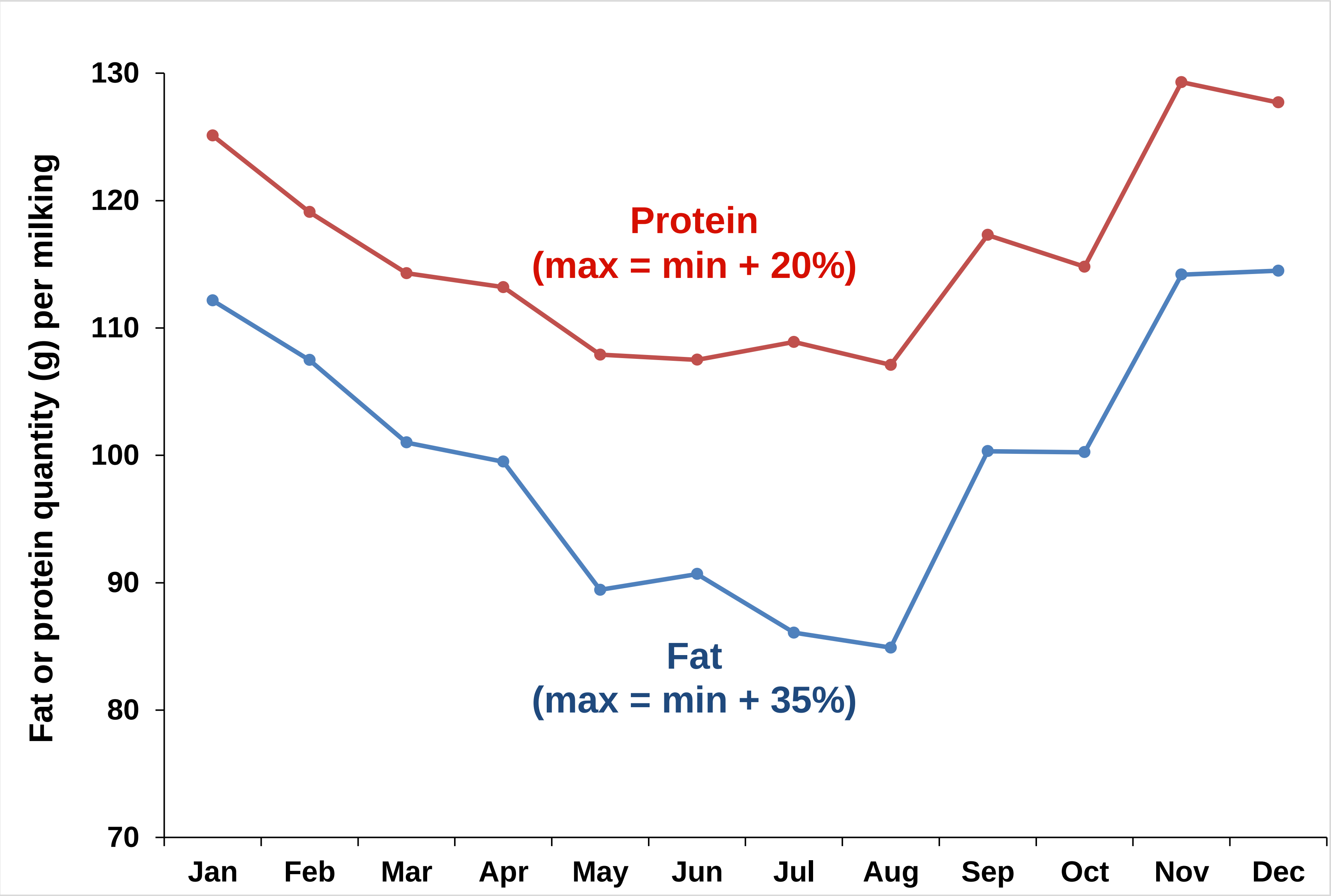

Figure 5: **Seasonal changes in fat and protein production capacity of dromedary camels**

- **Calculated values** [milk production (kg) × composition (%)].

- **Seasonal patterns** in protein and fat production.

- In winter:
  - low milk production, whereas
  - high fat and protein values (both in terms of % and absolute mass).

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- Increased **processing efficiency** (e.g. cheese yield) in winter.

- **Composition of final products** may also vary depending on season.

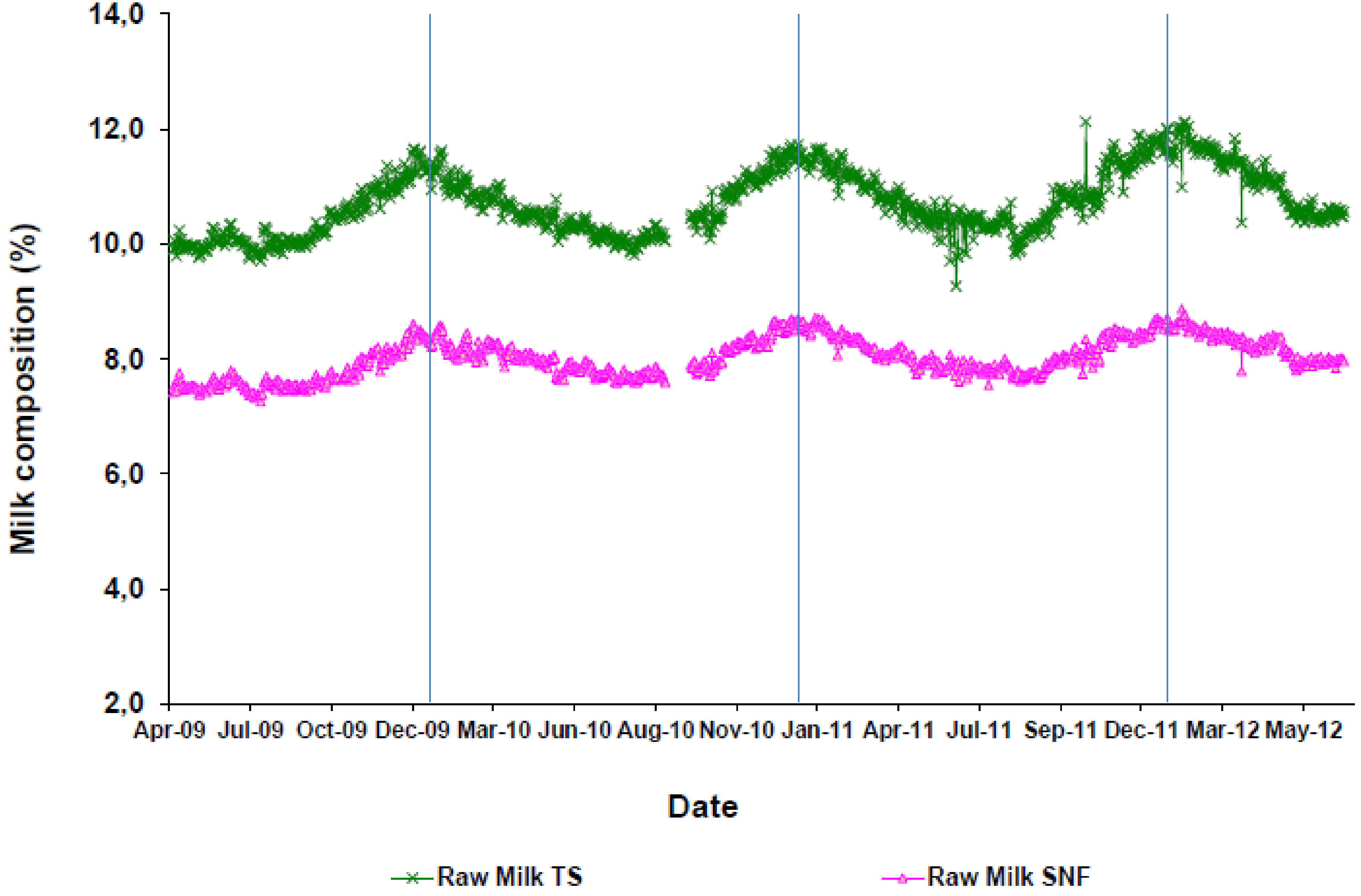

Figure 6: **Changes in total solids and solids-not-fat contents of raw camel milk between April 2009 and May 2012**

Mean compositional values of bulk camel milk at EICMP (2009-2012)

- Fat: **2.8** ± 0.33%
- Protein: **2.9** ± 0.26%
- Lactose: **4.2** ± 0.19%
- Solids-not-fat: **8.0** ± 0.39%
- Total solids: **10.6** ± 0.58%

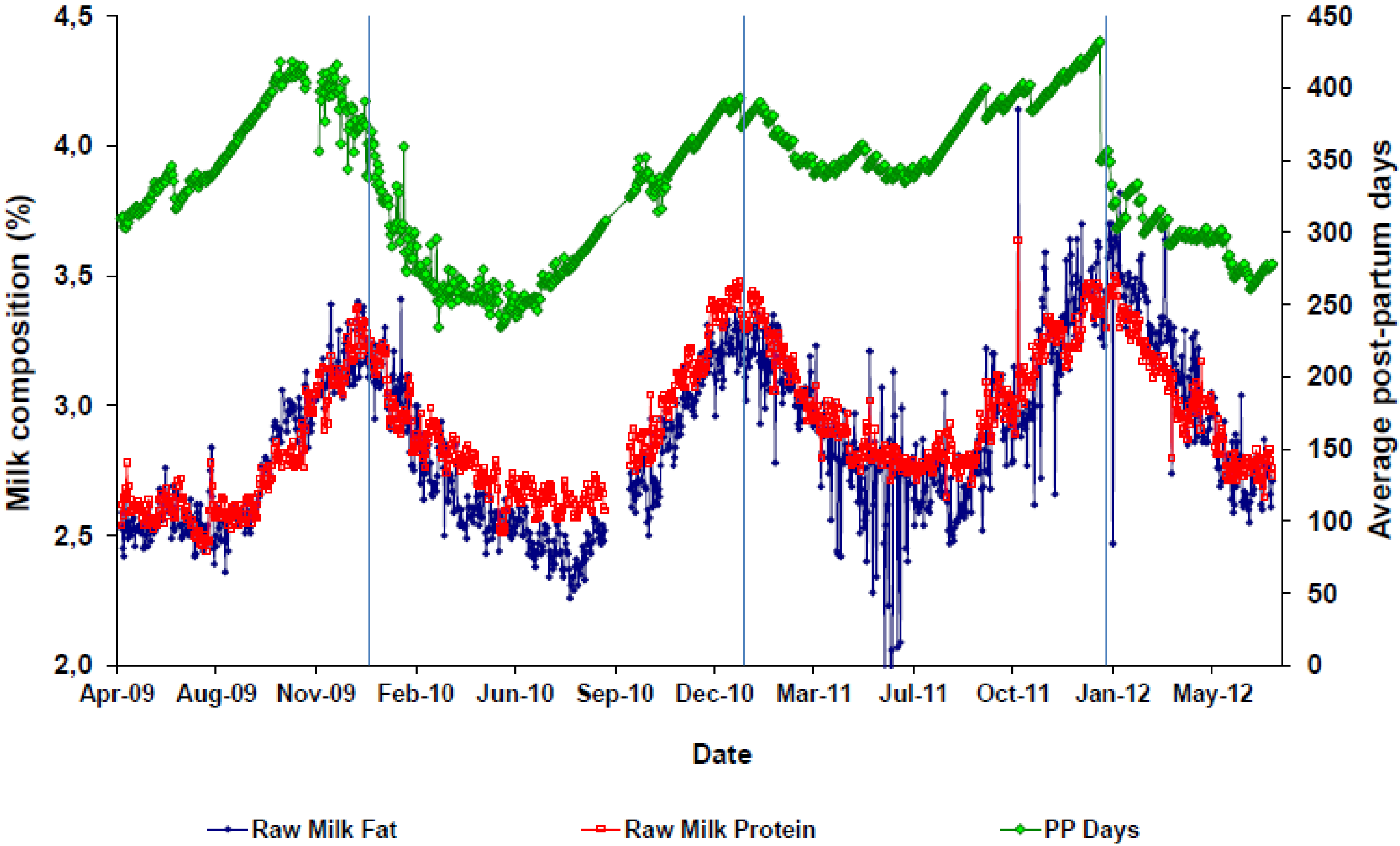

Figure 7: **Changes in fat and protein contents of raw camel milk and average post-partum days between April 2009 and May 2012**

- **Chemical composition** of milk is significantly influenced by both:
  - **season** and
  - **PPD**.

- However, the effects of these two factors could not be separated in this study.

- *Bottom line*: an increase in both fat and protein cc is observed with increasing numbers of PPD, with all values being highest in winter,

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- resulting in improved production/processing **yields**.

Factors affecting the chemical composition of camel milk

- ***Exogenous*** factors:
  - season
  - year

- ***Endogenous*** factors:
  - breed
  - age
  - parity
  - stage of lactation
  - level of milk production

3. Influence of milk composition on processing characteristics

Cheese-making

- Large **seasonal variations** in protein and fat contents (minima in August and maxima in mid-winter).

- These differences may alter the **sensory properties** of milk, and the **fat-to-casein** ratio may need to be **standardized** for cheese-making.

- *General requirements:*
  - Low SCC (preferably < 10^5 cells/mL);
  - Low microbial load (< 10^4 cfu/mL of milk), including psychrotrophs;
  - Free from pathogens and clostridia (*C. tyrobutyricum*);
  - Presence (abundance) of LAB;
  - No off-flavors;
  - Absence of antimicrobial agents;
  - High **protein content** [camel milk: β-lactoglobulin (absent) and κ-casein (low) → higher **cheese yield** and **curd firmness**, and reduced **coagulation time**].

- *Problems* encountered during cheese-making from camel milk include:
  - **Prolonged rennet coagulation time**:
    - limited availability of κ-CN (3.5% of caseins).
  - **Soft (fragile) curd**:
    - low TS (casein) content,
    - large casein micelles (up to 500 nm) → less firm coagulum,
    - small fat globules (< 3 μm).
  - **Reduced cheese yield**:
    - significantly (up to 50%) lower values compared to cheese made from cow milk,
    - *however*: protein recovery and yield may be increased by UF.

Yogurt manufacture

- The higher the ***PROTEIN*** content of the milk, the stronger will be the resultant yogurt gel because proteins, along with Ca and P, give rise to the basic yogurt **coagulum**.

- Therefore, the protein content of milk **must be increased** (by SMP fortification, vacuum evaporation or UF) to around **40-50 g/L**. EPS-producing starters or stabilizers (alginates, κ-carrageenan, etc.) may also be used.

- ***FAT*** plays no part in the formation of the yogurt gel. However, it is important with respect to **sensory quality**.

- Approx. **10-12 g/L** is enough to provide yogurt with a pleasant mouthfeel → the original fat content of raw milk **has to be reduced** before further processing.

- ***LACTOSE***, at around **42-45 g/L**, forms the bulk of SNF in camel milk. Its role is to provide a **substrate for the fermentation** stage. *Problem*: ***gelation of camel milk does not occur*** at the isoelectric point of caseins (pH 4.6), because the size of micelles is too small to form a dense protein network observed in yogurt made from cow milk.

- Many LAB require B-group vitamins for growth → seasonal changes in the cc of ***VITAMINS*** in milk may affect
  - the metabolism of the culture with respect to
    - the rate of acid production and
    - the synthesis of flavor compounds and, thus,
  - the quality of yogurt.

- The cc of ***MINERALS*** (e.g. Ca) can also influence yogurt quality (i.e. gel firmness).

4. Survival of the microbiota in probiotic fermented milks during refrigerated storage

(Varga et al., 2014)

Introduction

- LAB consumption through fermented milks is associated with improved health.
- Health-promoting ***Bifidobacterium*** and ***Lactobacillus*** **spp**. received attention as probiotic organisms → incorporated into dairy foods worldwide.
- Beneficial effects depend on the number of viable cells reaching the human gut: **$\geq 10^6$ cfu/mL** should be present at the time of consumption if a health claim is to be made.

- Interest in camel milk is increasing in many countries because this product is (*Fábri et al., 2014a,b*):
  - devoid of β-lactoglobulin, whereas its major whey proteins include **α-lactalbumin** and **serum albumin**;
  - rich in **β-casein**, which is the dominant casein in camel milk;
  - contains reduced amounts of short chain (C_4-C_{12}) FAs and increased levels of medium and long chain (C_{14}-C_{18}) FAs;
  - higher in **Na** and **Ca** than are milks of other species;
  - a good source of certain vitamins (e.g. **vitamin C**).

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- The compositional differences between camel milk and other milks influence the **growth** and **viability** of LAB and bifidobacteria.

- **Objective**: monitoring the **viability** during refrigerated storage of
  - *Lactobacillus acidophilus* LA-5 (**A**),
  - *Bifidobacterium animalis* subsp. *lactis* BB-12 (**B**), and
  - *Streptococcus thermophilus* CHCC 742/2130 (**T**)

  in probiotic cultured dairy foods made from **four varieties of milk** fermented by an ABT-type culture.

Materials and methods

- Raw materials:
  - dromedary **camel milk** (EICMP, Dubai, UAE),
  - **cow milk** (Lajta Hanság, Inc., Mosonmagyaróvár, HU),
  - **goat milk** (Tebike, Inc., Győr-Ménfőcsanak, HU),
  - **sheep milk** (PharmaGene-Farm, Inc., Mosonmagyaróvár, HU).
- Raw milks heated at **80°C** for **10 min**.
- Freeze-dried DVS culture (**ABT-5**; Chr. Hansen, Hørsholm, DK).
- Inoculation rate: 0.2 U/L [= **2.0%** (v/v) bulk starter].
- Milks fermented at **37°C** until pH 4.6.
- Refrigerated storage at **4°C**.

- Microbiological tests: after 0, 7, 14, 21, 28, 35, and 42 d of storage according to *Süle et al. (2014)*:
  - *S. thermophilus*: **M17 agar** incubated at 45°C for 24 h aerobically;
  - *L. acidophilus*: **MRS-clindamycin-ciprofloxacin agar** incubated at 37°C for 72 h in anaerobiosis;
  - *B. animalis* subsp. *lactis*: Transgalactosylated oligosaccharides-mupirocin lithium salt (**TOS-MUP**) **agar** incubated at 37°C for 72 h under anaerobic conditions.

- Statistical analysis:
  - results subjected to ANOVA (STATISTICA 9.0; StatSoft, Tulsa, OK);
  - time and product as fixed factors and repetition as covariate in the model;
  - significant differences among $\log_{10}$ cfu/mL means determined by Duncan's multiple comparison test at $P < 0.05$ (StatSoft).

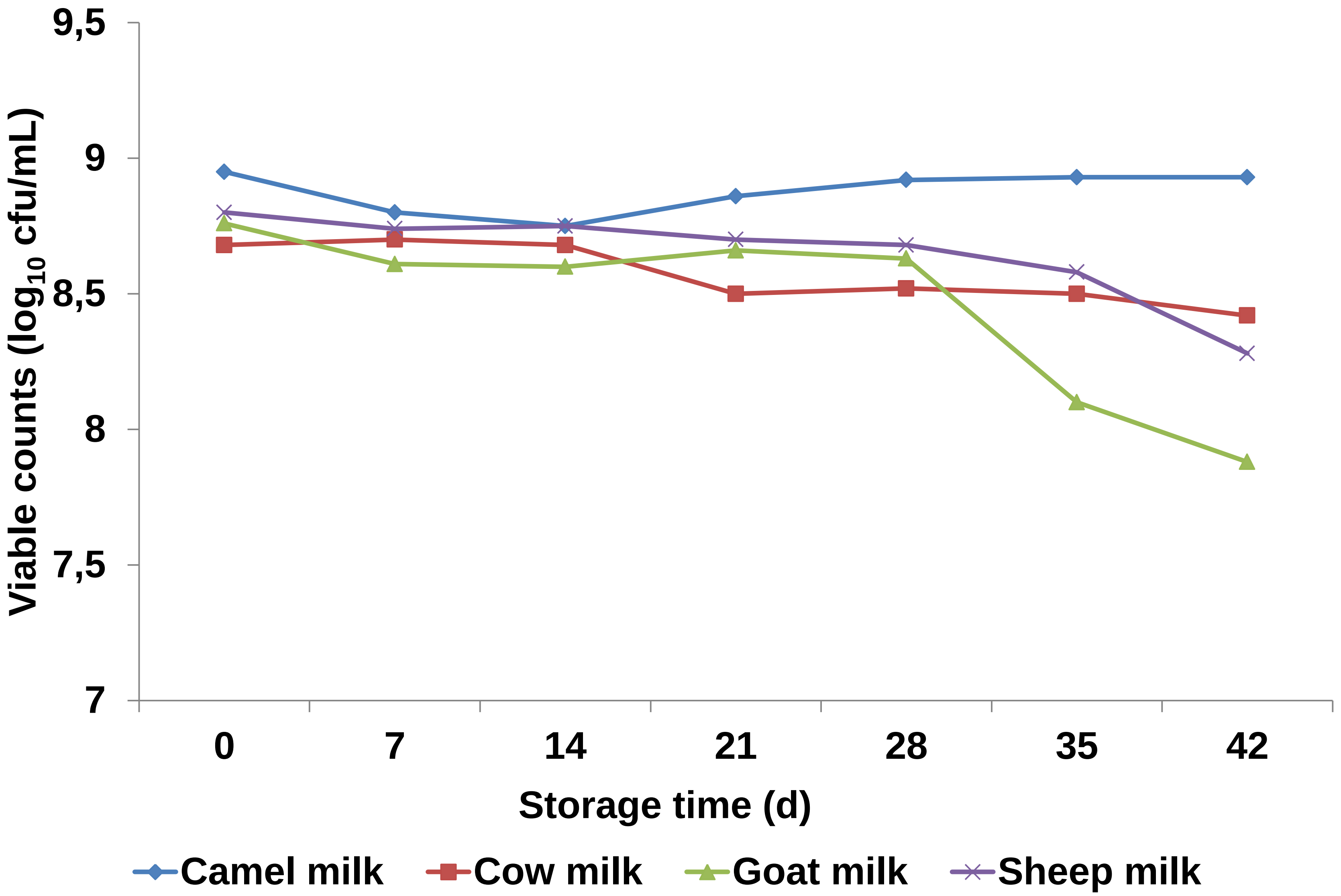

Figure 8: **Survival of *Streptococcus thermophilus* in probiotic fermented milks during storage at 4°C**

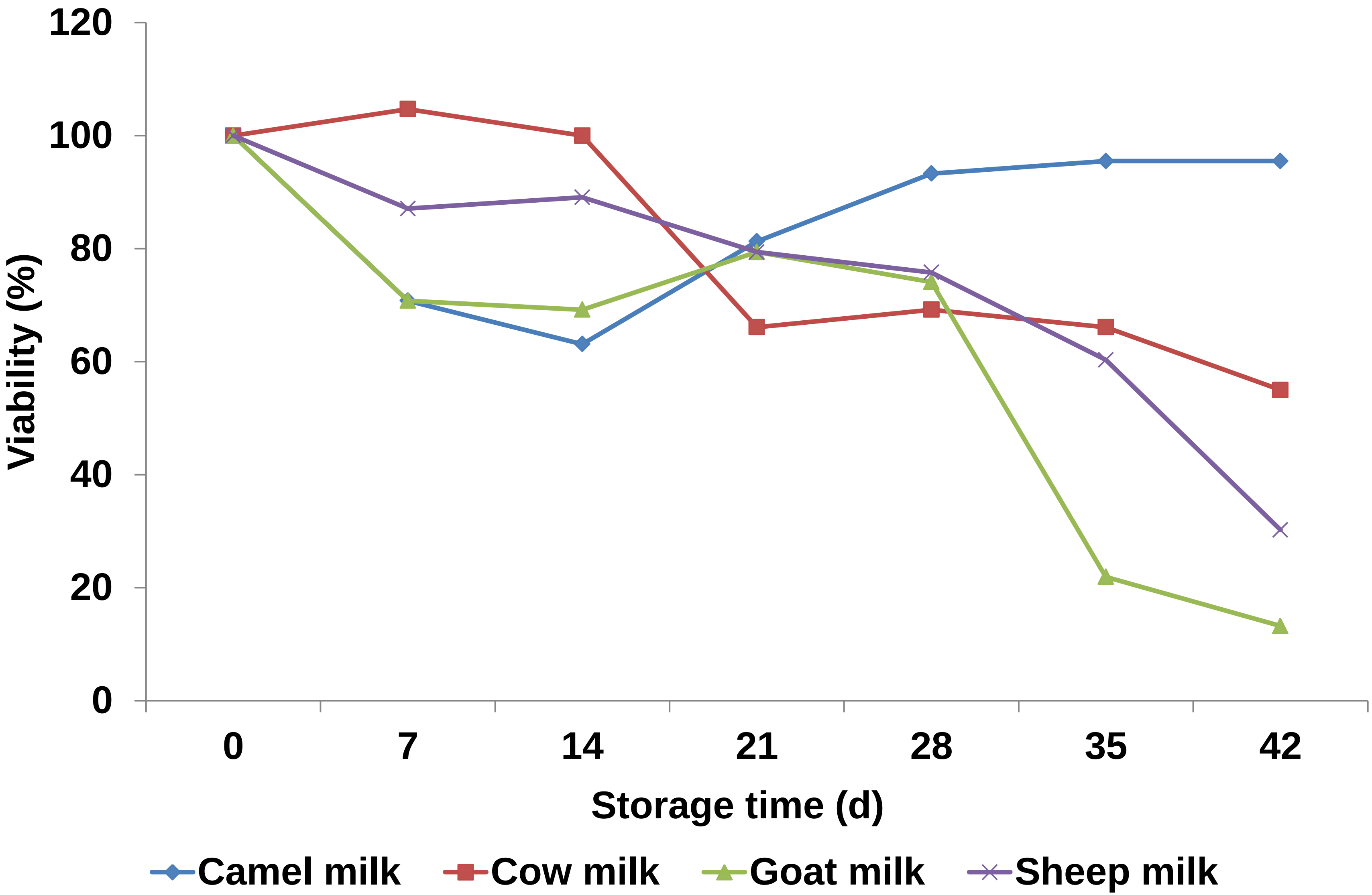

Figure 9: **Viability percentages of *Streptococcus thermophilus* in probiotic fermented milks during storage at 4°C**

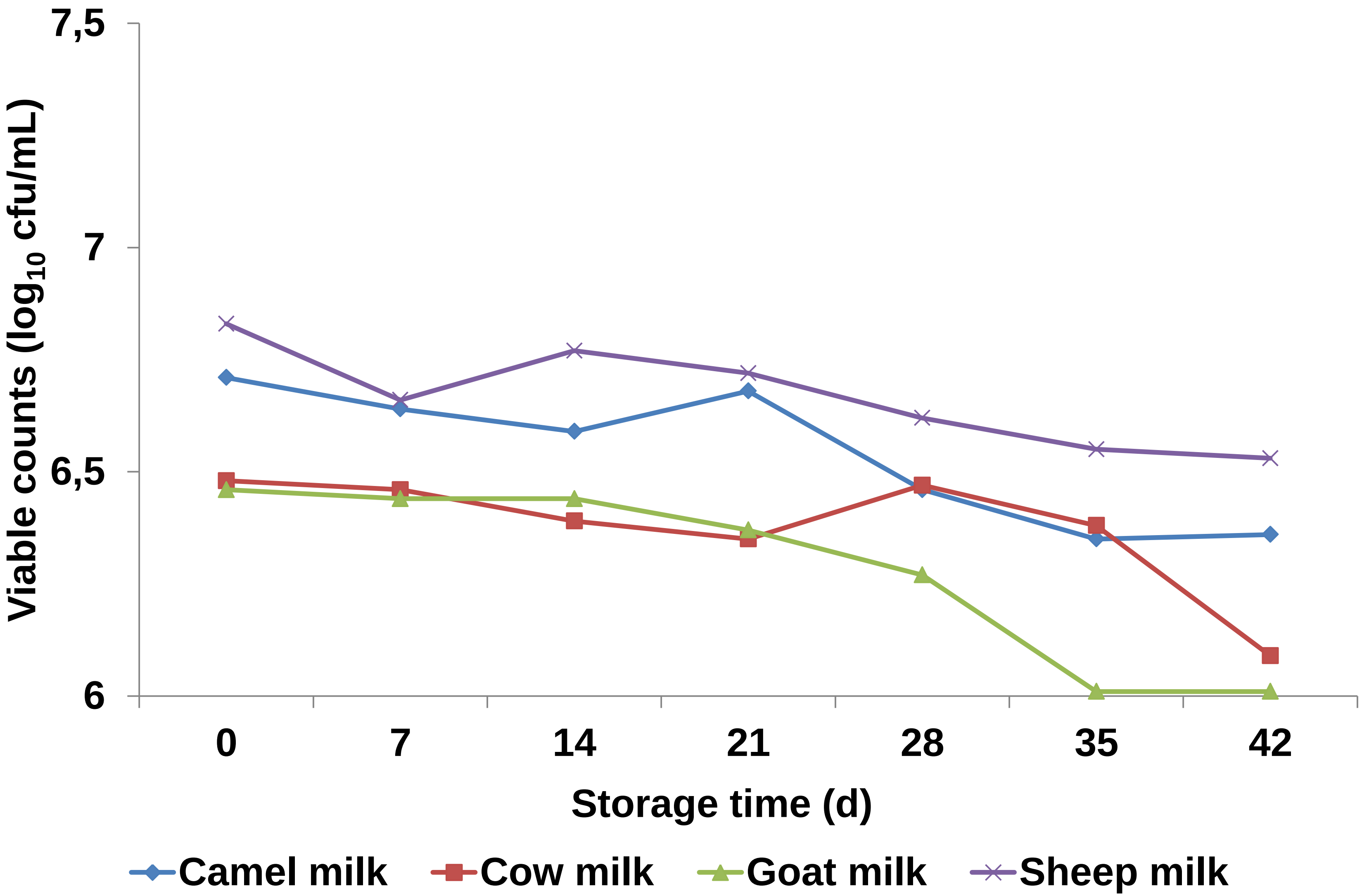

Figure 10: **Survival of *Lactobacillus acidophilus* LA-5 in probiotic fermented milks during storage at 4°C**

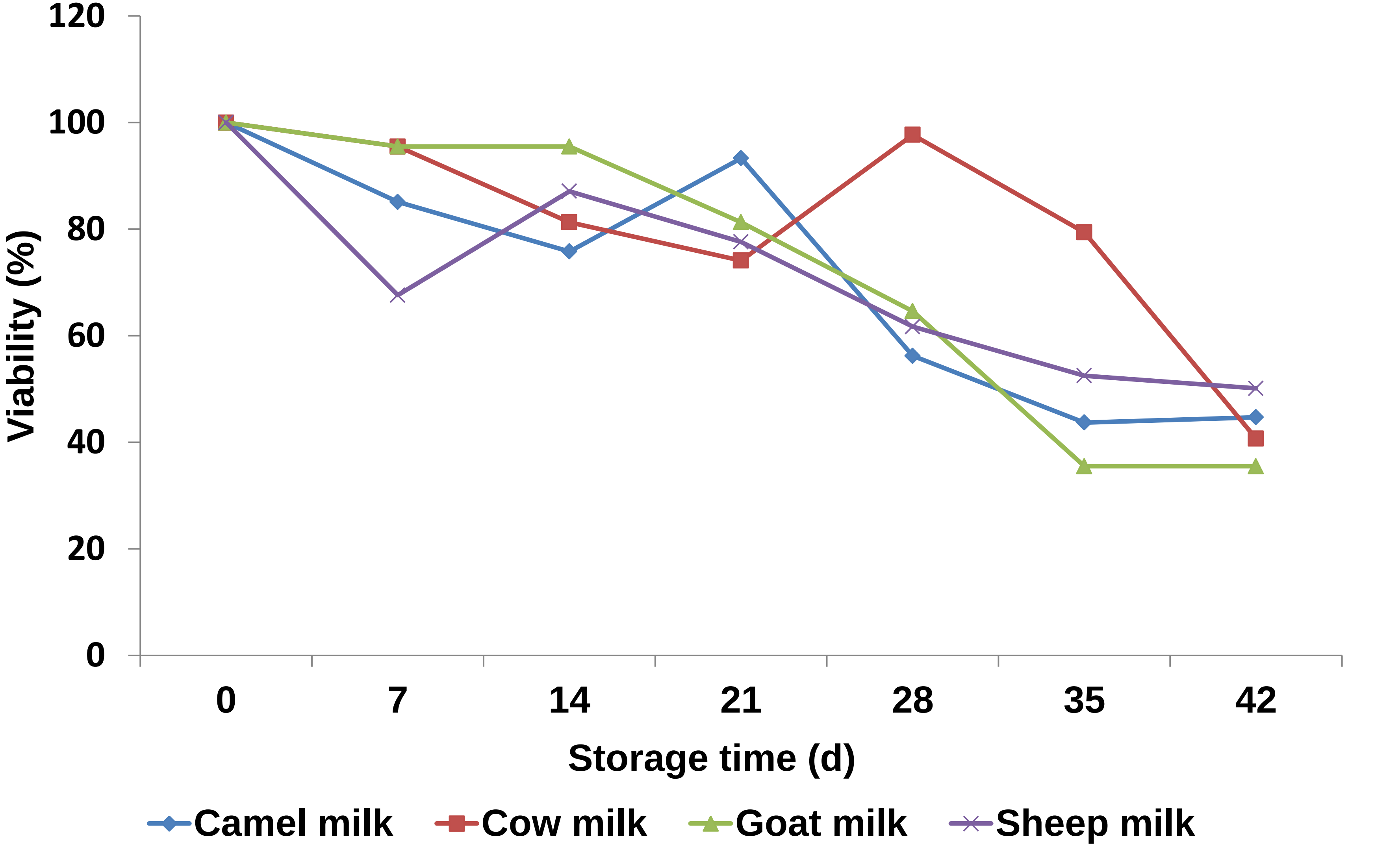

Figure 11: **Viability percentages of *Lactobacillus acidophilus* LA-5 in probiotic fermented milks during storage at 4°C**

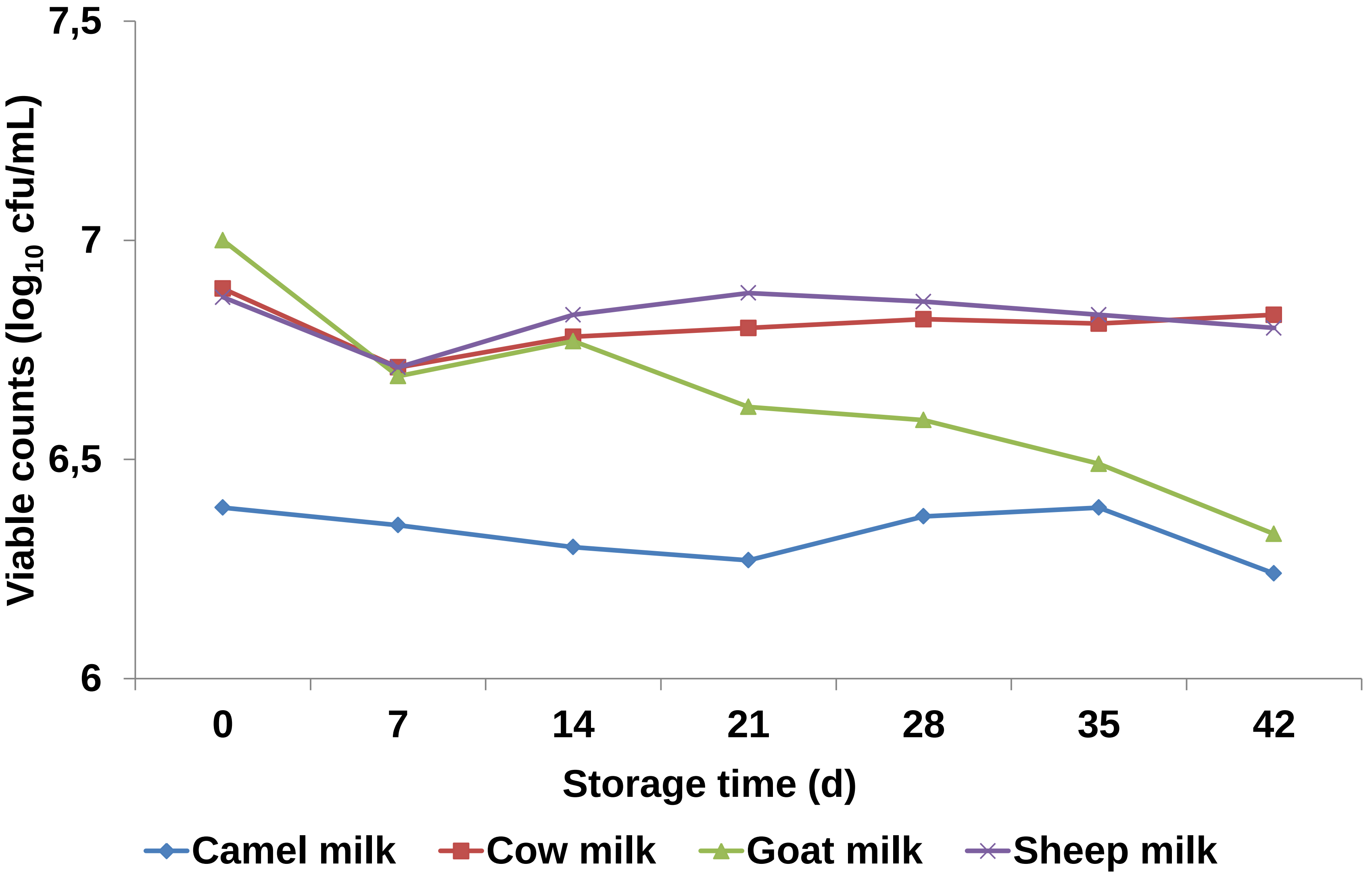

Figure 12: **Survival of *Bifidobacterium animalis* subsp. *lactis* BB-12 in probiotic fermented milks during storage at 4°C**

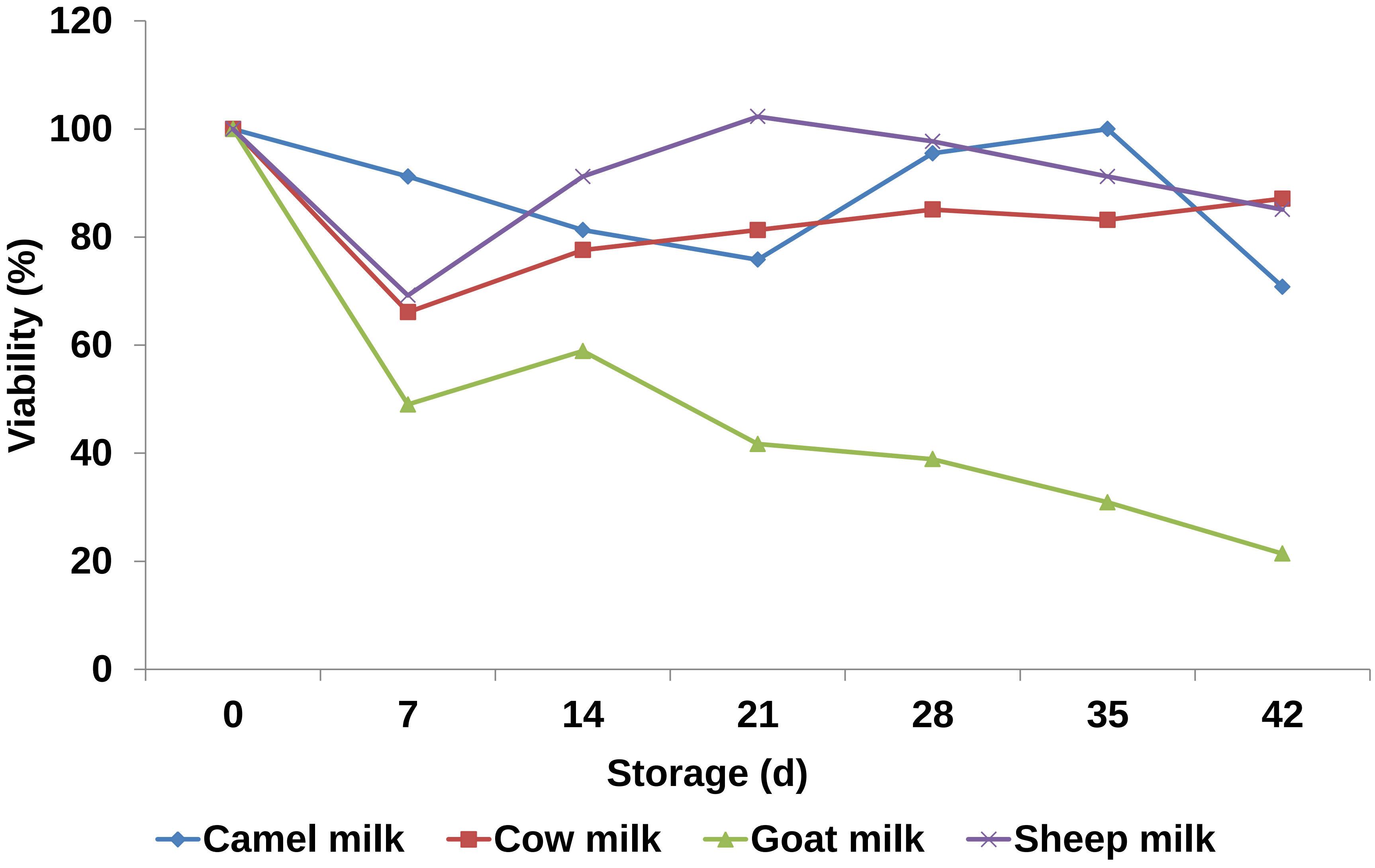

Figure 13: **Viability percentages of *Bifidobacterium animalis* subsp. *lactis* BB-12 in probiotic fermented milks during storage at 4°C**

Conclusions

- All four varieties of milk proved to be **suitable raw materials** for the manufacture of high-quality ABT-type fermented dairy products.

- The development of **camel milk based probiotic cultured milks** appears to be very promising. However, sensory studies, technology development activities, and market researches are needed before such food products can be successfully commercialized.

- *First study to evaluate the survival of probiotic lactobacilli and bifidobacteria in fermented camel milk.*

Thank you for the attention

References

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