Effect of pasteurization and simulated digestion on insulin content of camel milk

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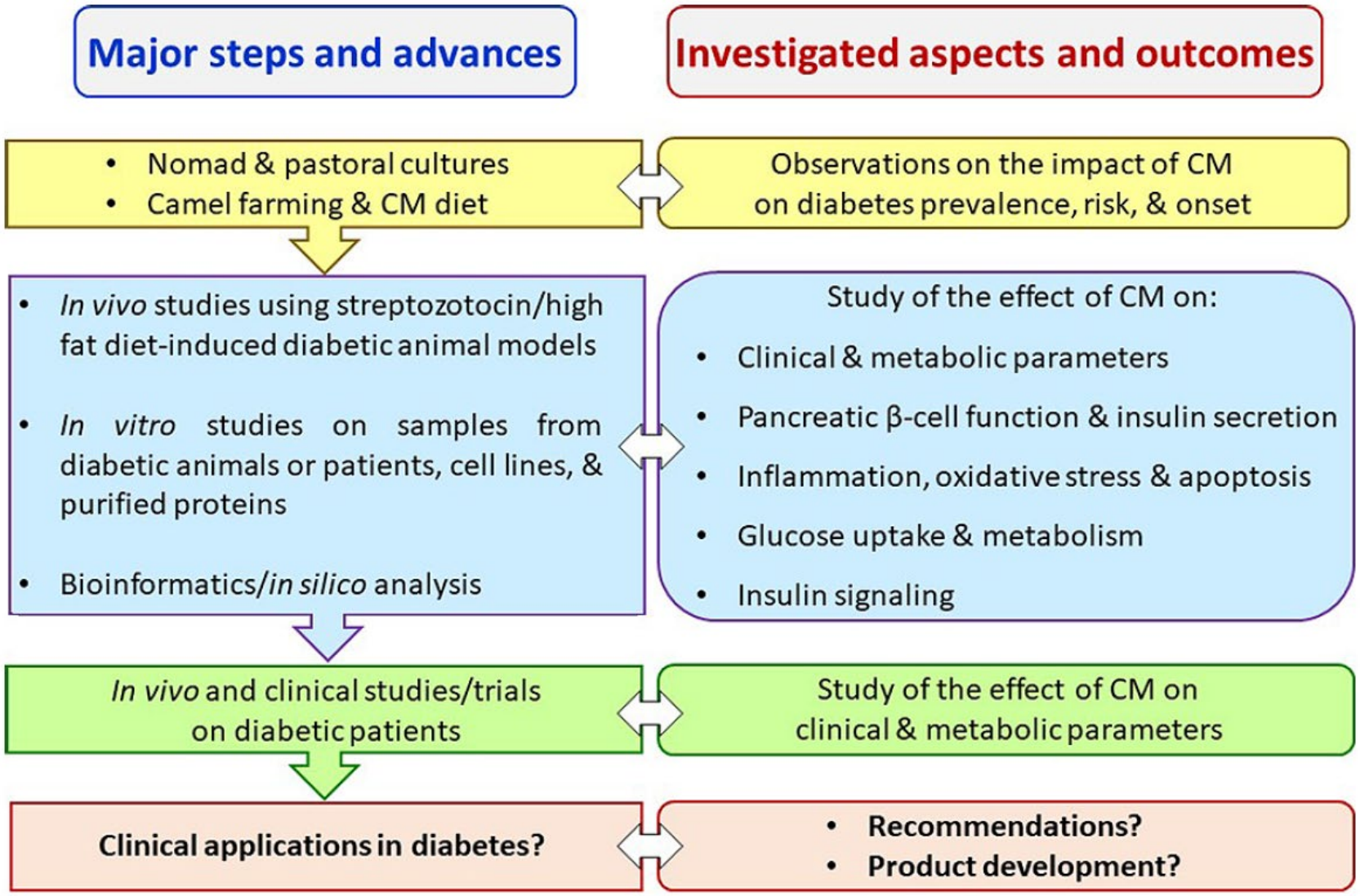
Introduction: Antidiabetic properties of camel milk

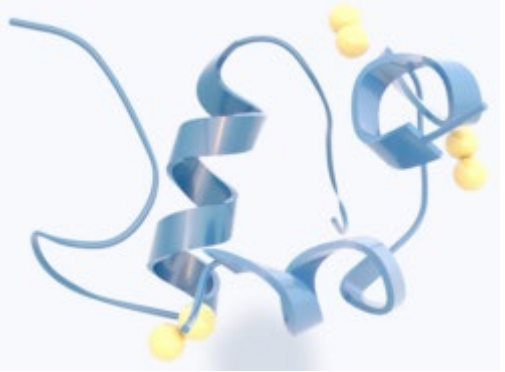


Specific recommendations and the development of CM-derived antidiabetic drugs for possible clinical applications

Ayoub et al. (2024)

Introduction: Insulin in camel milk

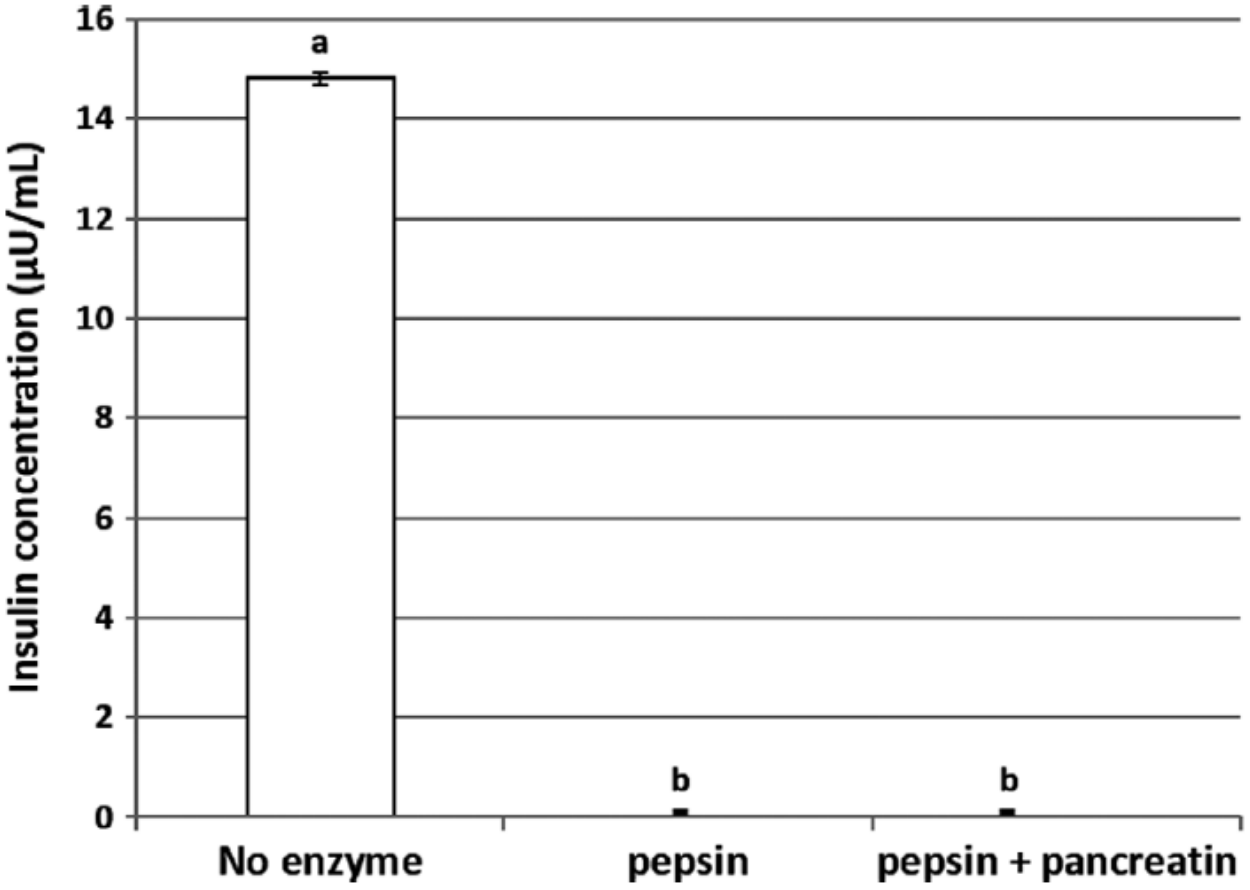
- Antidiabetic action of camel milk:
  - Valuable amount of insulin: 45–128 μU/mL.
  - Drinking 500 mL/d in clinical studies helps control diabetes.
  - Camel's milk has a hypoglycaemic activity in experimental diabetic animals.



wikipedia.org/wiki/Insulin

- How it works:
  - Insulin or insulin-like protein resists proteolytic degradation in the stomach.
  - Insulin is likely to be encapsulated in lipid nanoparticles.
  - Camel's milk contains low molecular components that simulate insulin interaction with its receptor.

Introduction: Insulin is lost during digestion



- It seems that milk insulin is totally degraded during the digestion process.
- Is insulin degraded to the same extent in all camel milk regardless the physiological state of the animal or milk heat treatment?

Abou-Soliman et al. (2020)

Objectives

- To test whether **variation factors** could affect **milk insulin** concentration in the **stomach** and **intestine**:
  - Stage of lactation
  - Pasteurization
- INFOGEST **static** in vitro simulation of gastrointestinal food digestion (Brodkorb et al., 2019):
  - Gastric phase for **2 h**
  - Intestinal phase for **2 h**

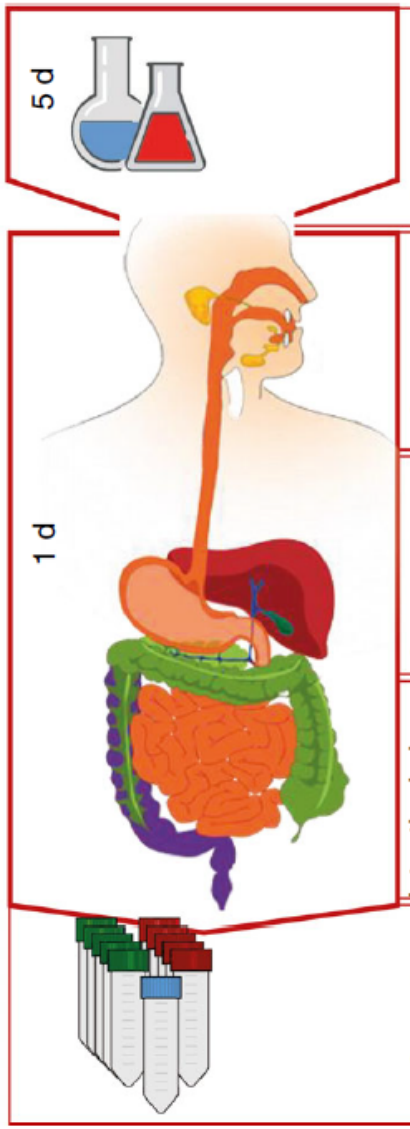
Materials and Methods: Milk samples and heat treatment

- **Three camel milk pools:**
  - Early lactation: 7 to 60 DIM (n = 8; 43 ± 6 DIM)
  - Late lactation: > 180 DIM (n = 7; 210 ± 16 DIM)
  - Milk from the local market (commercial)

} Same dairy farm

- **Milk pasteurization:**
  - 72ºC for 15 sec
  - Cooled immediately by placing on ice
- **Samples for analyses:**
  - 3 pools x 2 heat treatments (raw vs. pasteurized) x 3 replicates = 18 samples

Materials and Methods: Simulated digestion (INFOGEST)



		Step
Preparation	• Perform enzyme activity and bile assays	1
	• Prepare SSF, SGF and SIF stock solutions	2
	• Perform pH-test adjustment experiment	4
Oral phase	• Mix Food with SSF (1:1, (wt/wt))	7–12
	• Include $CaCl_2$ (1.5 mM in SSF)	13
	• Add salivary amylase, if necessary (75 U/mL)	14
	• Incubate while mixing (2 min, 37 °C, pH 7)	15, 16
Gastric phase	• Mix oral bolus with SGF (1:1 (vol/vol))	17, 18
	• Include $CaCl_2$ (0.15 mM in SGF)	19
	• Add pepsin, gastric lipase (2,000, 60 U/mL)	20, 21
	• Incubate while mixing (2 h, 37 °C, pH 3.0)	22–24
Intestinal phase	• Mix gastric chyme with SIF (1:1 (vol/vol))	25, 26
	• Include bile (10 mM bile salts)	27
	• Include $CaCl_2$ (0.6 mM in SIF)	28
	• Add pancreatin (trypsin activity 100 U/mL)	29
	• Incubate while mixing (2 h, 37 °C, pH 7.0)	30–32
Sampling	• Sampling procedure and sample treatment (Table 1)	

Skim milk

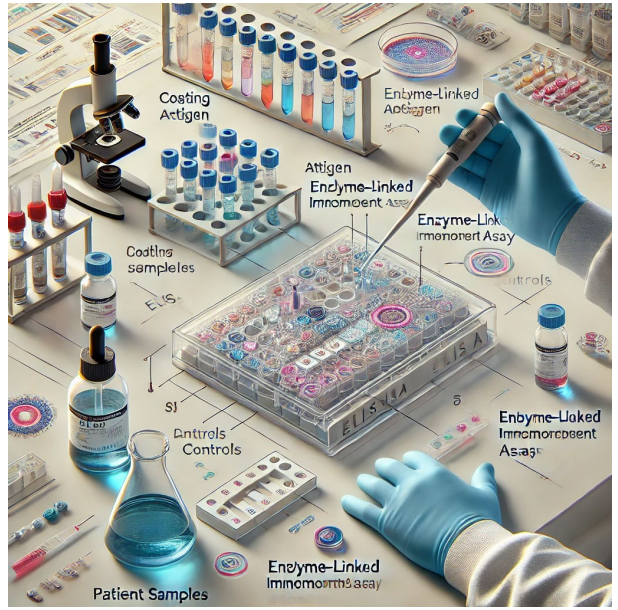
G-0h

G-2h

I-2h

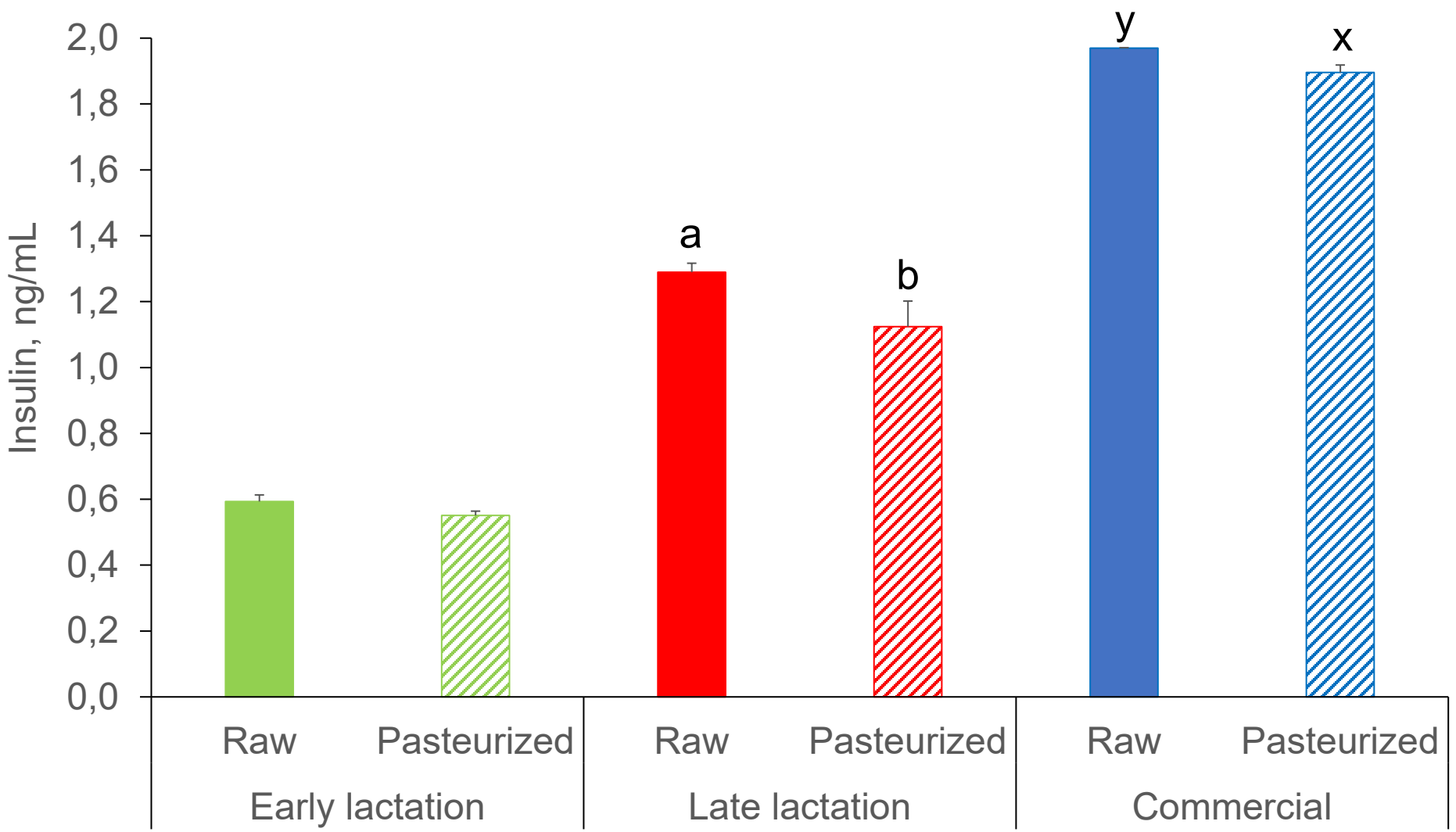
Materials and Methods: Milk samples and heat treatment

- **Insulin analysis:**
  - ELISA (Mercodia Diagnostics)
  - Reacted ELISA plates were read by an automatic reader at 450 nm



- **Statistical analyses:**
  - Proc Mixed of SAS (v. 9.4) for repeated measurements
  - Test for normalization and data transformation if needed
  - Statistical model: milk type (early, late, commercial), heat treatment (raw vs. pasteurized), phase (initial, G120, I120), and interactions

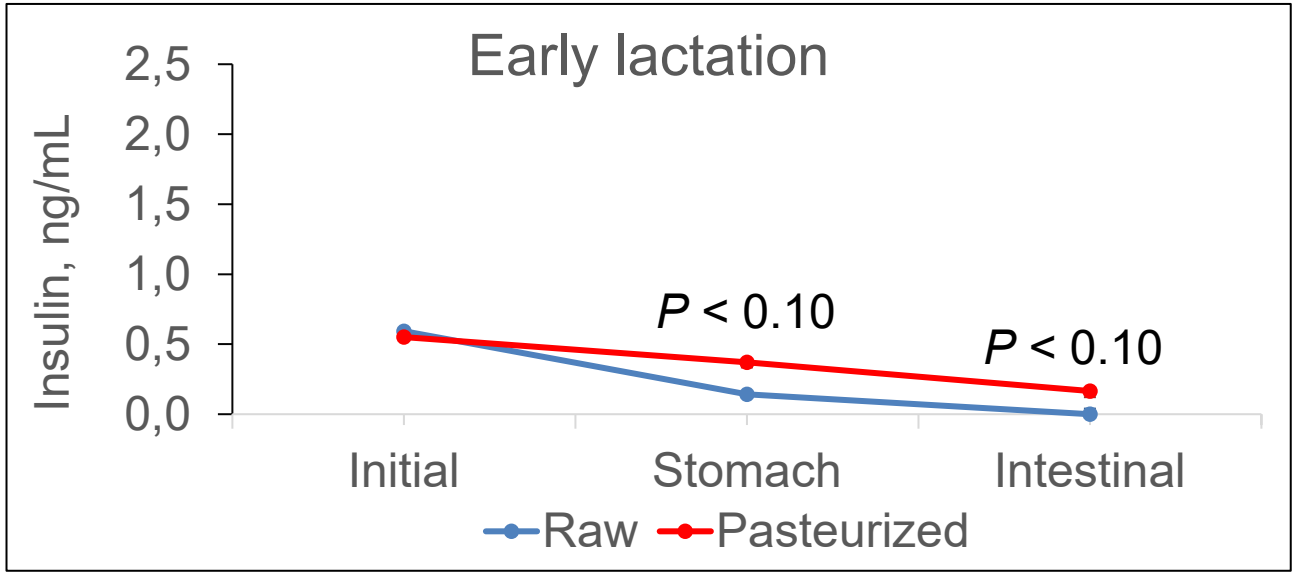
Results: Insulin in milk according to lactation stage and pasteurization

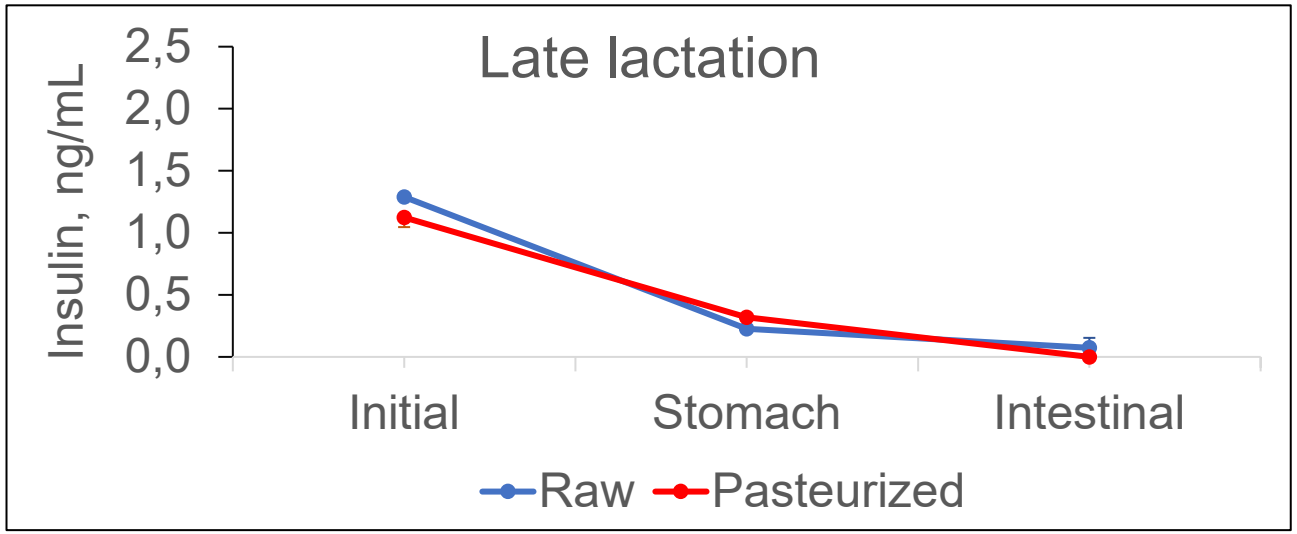


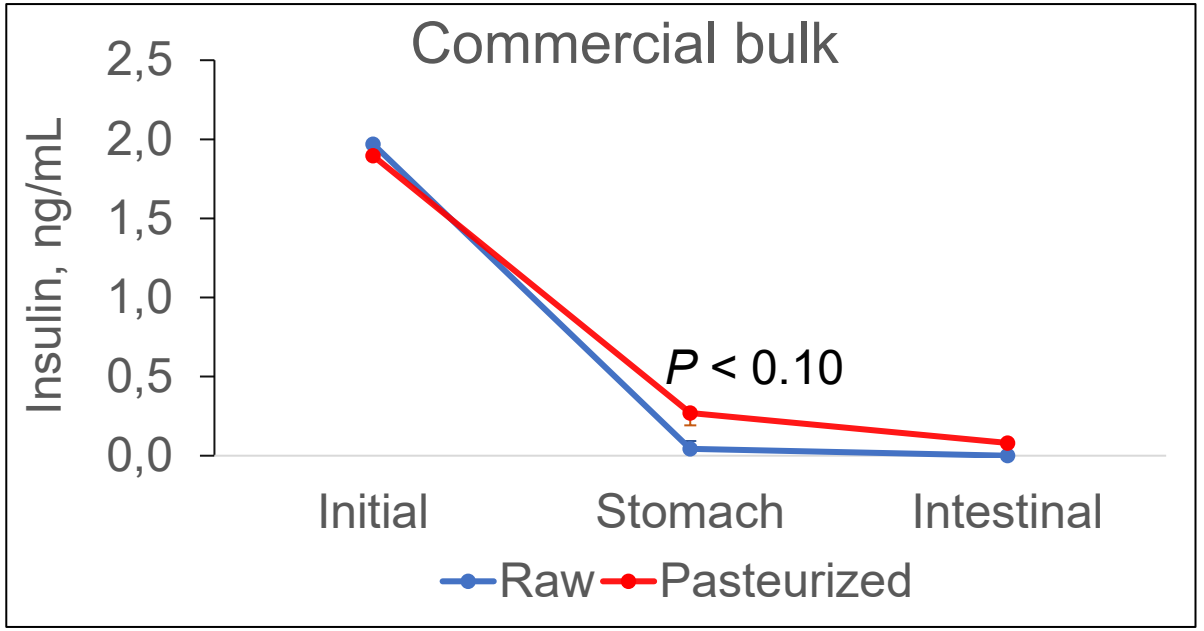
Pasteurization: $P < 0.003$
Stage: $P < 0.001$
Interaction: $P = 0.141$

a, b $P < 0.05$. x, y $P < 010$

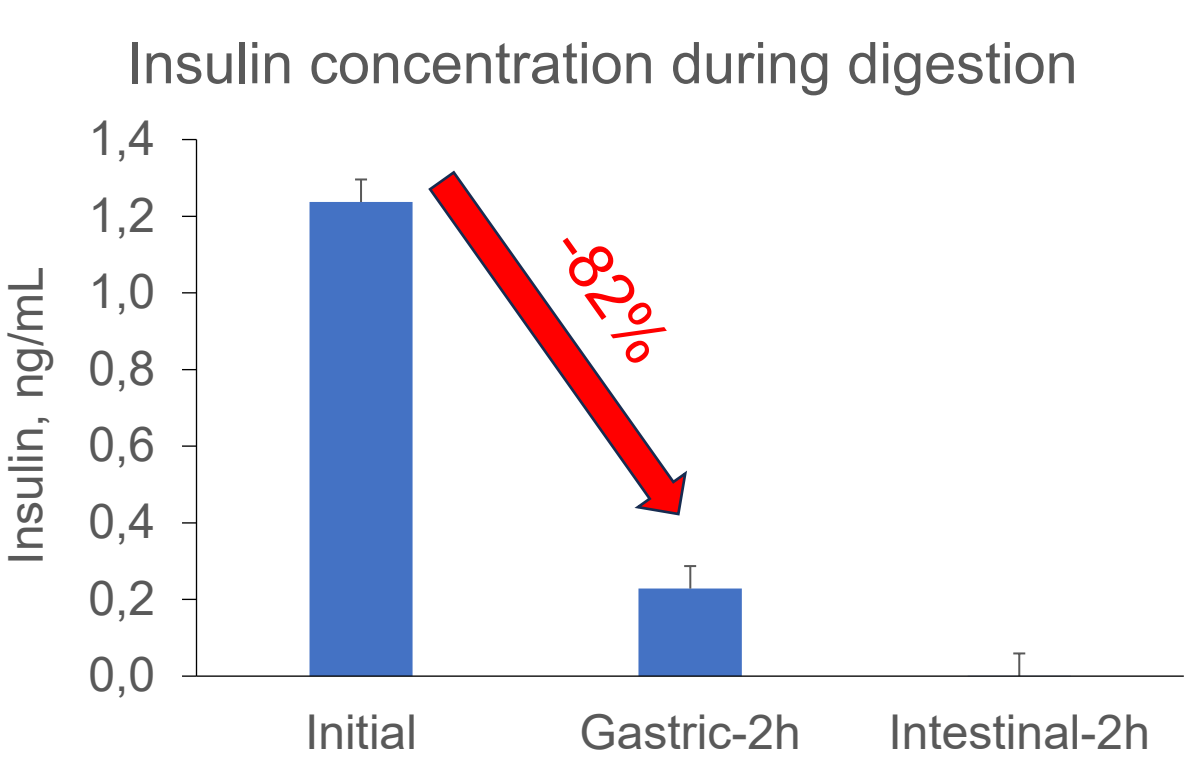
Results: Insulin in digested milk

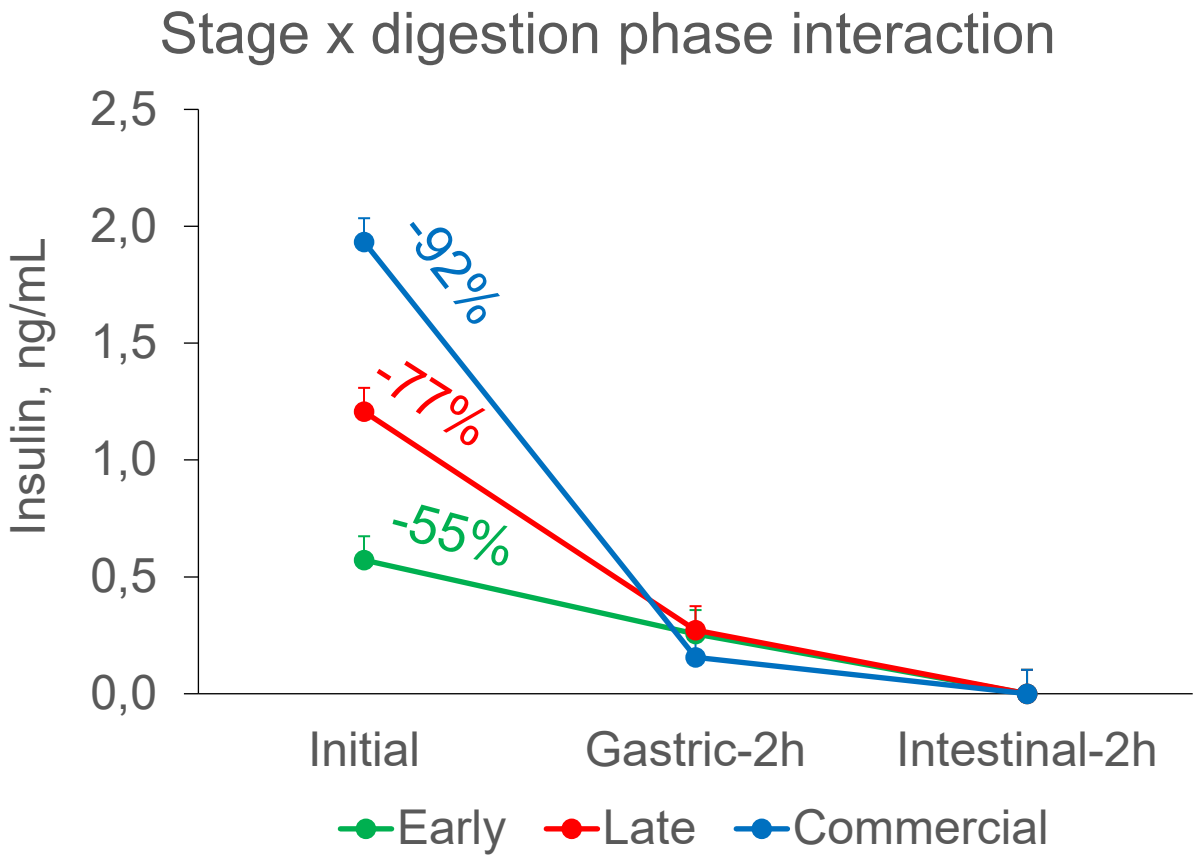






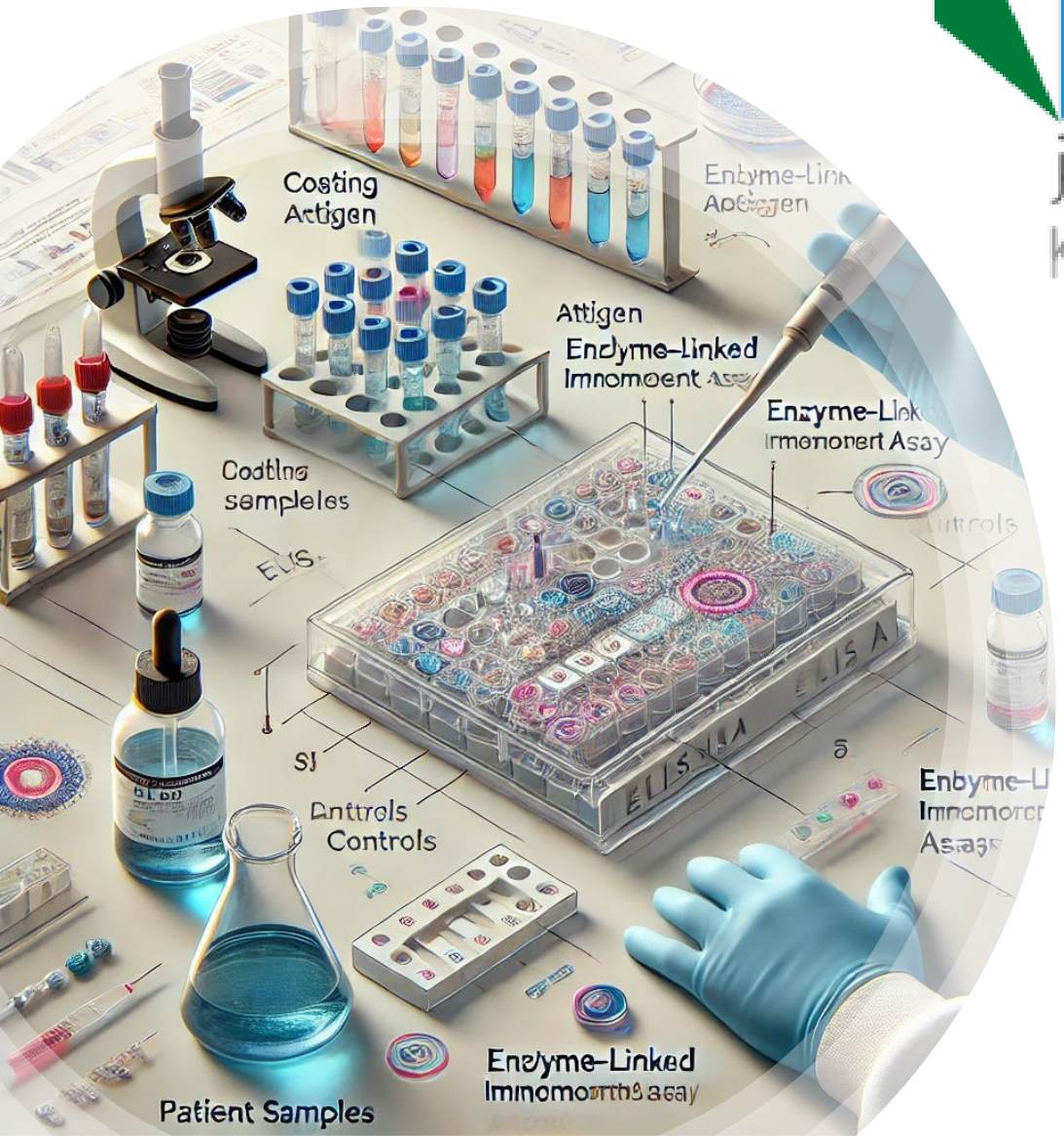
Results: Insulin in digested milk





Conclusions

- **Insulin concentrations:**
  - Milk form **early** lactation contained **lower** insulin levels than late lactation under the same management conditions.
  - **Pasteurization reduced** camel milk insulin concentration by **only 7%**.
  - Pasteurization tended to have a **protective effect** against the stomach digestion enzymes.
- **Small concentrations of milk insulin are available for the absorption in the intestine:**
  - Insulin is absorbed in the stomach?
  - Milk remains < 2h in the stomach. Kinetics of insulin digestion are needed.
  - Antidiabetic effect of camel milk could be related to other bioactive peptides produced during the digestion process.



Thank you for your attention!