Is PUFA transfer from grass to milk different during grazing compared with indoor feeding?

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Personal background

Farmers' daughter

1985: MSc at Wageningen University, plant breeding

1990: PhD at WU, grass seed production

1991-2011: Associate Prof. Grassland Science at WU

- teaching
- chain-approach research on forage-feed-milk
- projects with industries and farmers

2011 onward: independent scientist

- open for collaboration on freelance basis

Outline

- Review paper
- Fate of fatty acids (FA) from grass to cows' milk
- Pasture-fed cows *versus* indoor grass-fed cows?
- PUFA in herbage; intake; rumen processes
- Comparison of studies on feed composition, grazing and FA profile in milk
- Conclusive remarks

Elgersma A, 2015. Grazing increases the unsaturated fatty acid concentration of milk from grass-fed cows: A review of the contributing factors, challenges and future perspectives. **Eur. J. Lipid Sci. Technology 117**, 1345-1369

Khiaosa-ard R., Kreuzer M. and Leiber F, 2015. Apparent recovery of C18 PUFA from feed in cow milk: a meta-analysis of the importance of dietary FA and feeding regimens in diets without fat supplementation. **J Dairy Sci. 98**: 6399-6414

Why are we interested in fatty acids?

Human health

Cardiovascular diseases

PUFA, omega-3 (n-3)

Trans FA (trans-11 versus trans-10)

Results from The Netherlands

Capuano e.a., Rikilt-WUR, 2014 (Researchgate)

FA profiles - Food Chem
Triglyceride profiles - Eur Food Res Techn
Phytanic acid – Int Dairy J

30 farms sampled in April, May, June/July and February

Different farming and feeding systems

Contrasts for indoor / outdoor, contrast for fresh grass in diet?

Can milk from various systems be distinguished?

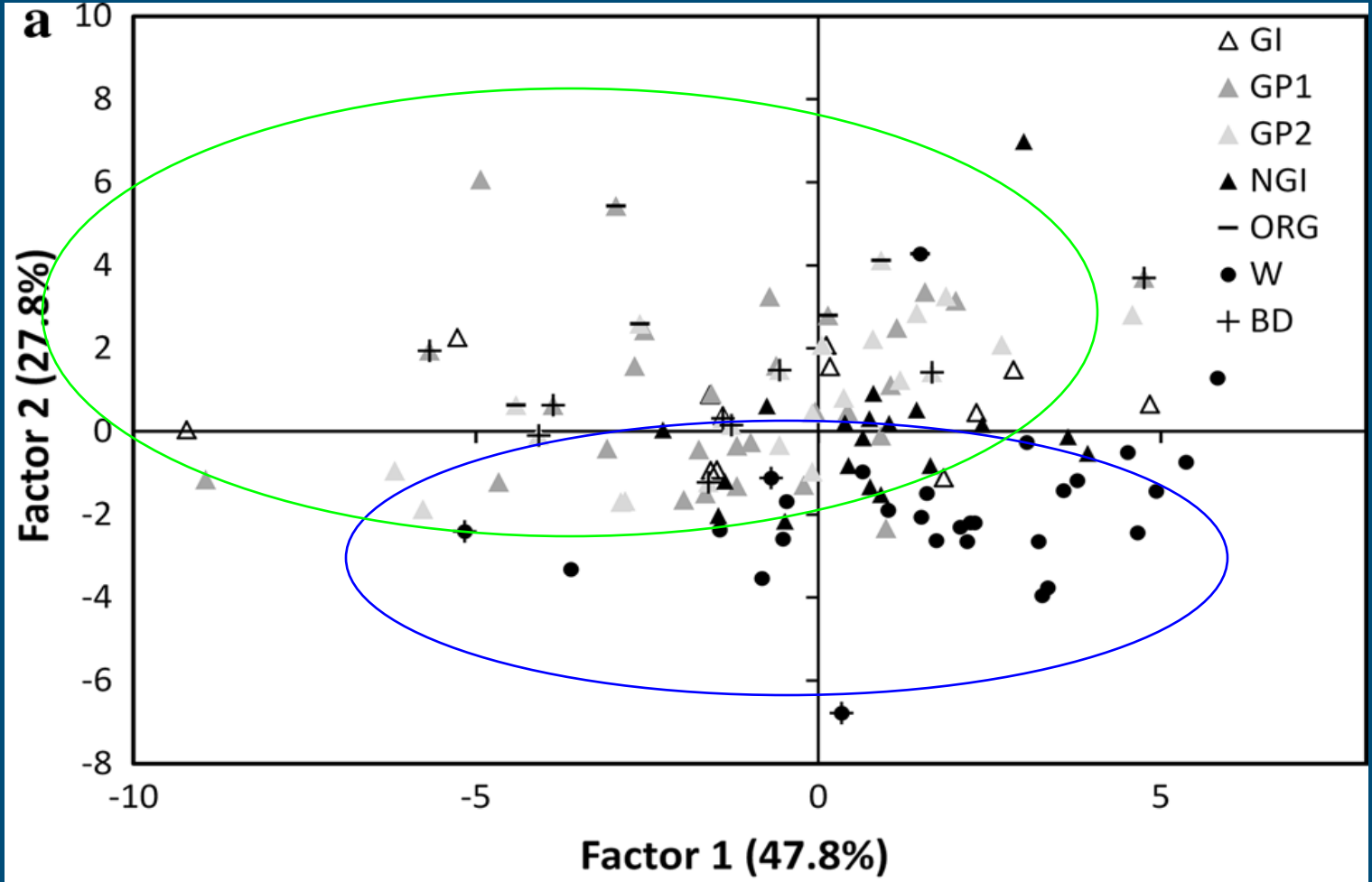
NG, no fresh grass;
GI, cows indoors with cut fresh grass;
Pd, pasture daytime;
Pd+n, pasture day + night;
Org / BD: Pd+n in an organic (Org) or biodynamic (BD) farming system

Contrasts for indoor / outdoor, contrast for fresh grass in diet

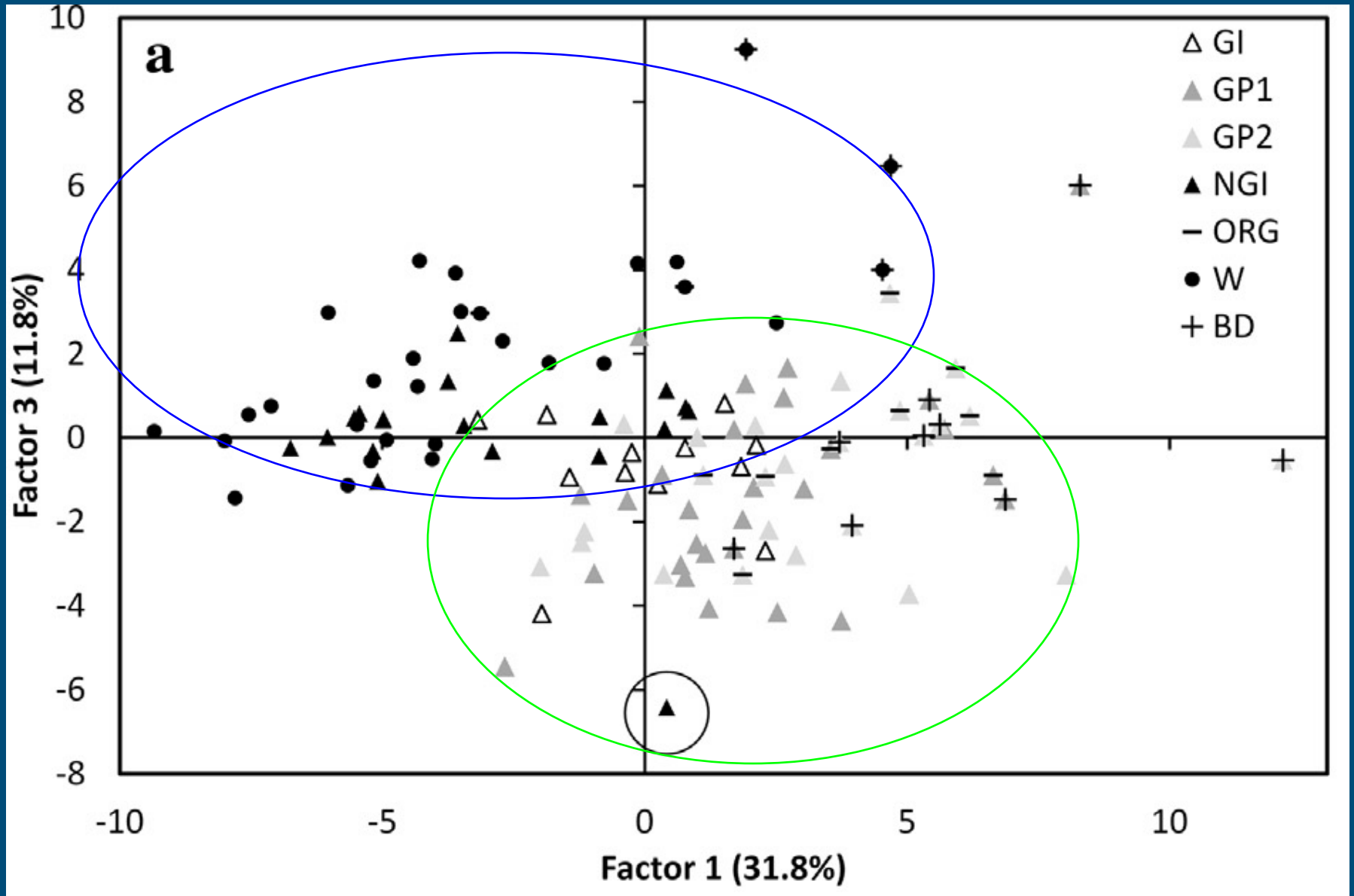
Triglyceride profiles, PCA scores

Contrast: no grass (Winter, No Grass Indoor) – grass in diet

Not suitable to distinguish milk from grazing, organic or BD farming systems



FA profiles, PCA scores : grass versus No Grass in diet, Winter



FA profiles, PCA scores

Contrasts:

Fresh grass - no fresh grass

Organic/BD milk : tendency but no discrimination based on FA; overlap with conventional grazing systems

‘Grazed milk’ authentification: no discrimination possible based on FA, overlap with ‘grass indoor’.

Pasture-based milk not different from indoor systems with fresh grass - based on a limited number of farms

Apparent recovery of FA relative to intake

- Meta-analysis by Khiaosa-ard et al. (2015)
- LA (C18:2*c*9*c*12) , ALA (C18:3*c*9*c*12*c*15) and C18 FA proportions in milk increased linearly with dietary content
  - Highest slope in forage-based indoor feeding
  - Lowest slope and highest intercepts with grazing
- Do under grazing other factors than diet play a role?

Apparent recovery of FA relative to intake

- Grazing: most RA-CLA (C18:2*c*9*t*11) and VA (C18:1*t*11) in milk fat regardless of C18 PUFA supply
- Apparent recovery decreased with increasing content in diet
- Different feeding regimes had a different potential to modify milk PUFA composition; grazing was most variable

Effects of grazing or indoor feeding on milk?

- Various studies
- Meta-analyses
- PUFA intake quantification:
  - Herbage intake
  - Contents of FA in ingested feed (herbage)
- Under grazing, measurements are more difficult
- Methodological constraints
- Different methods in different studies / labs

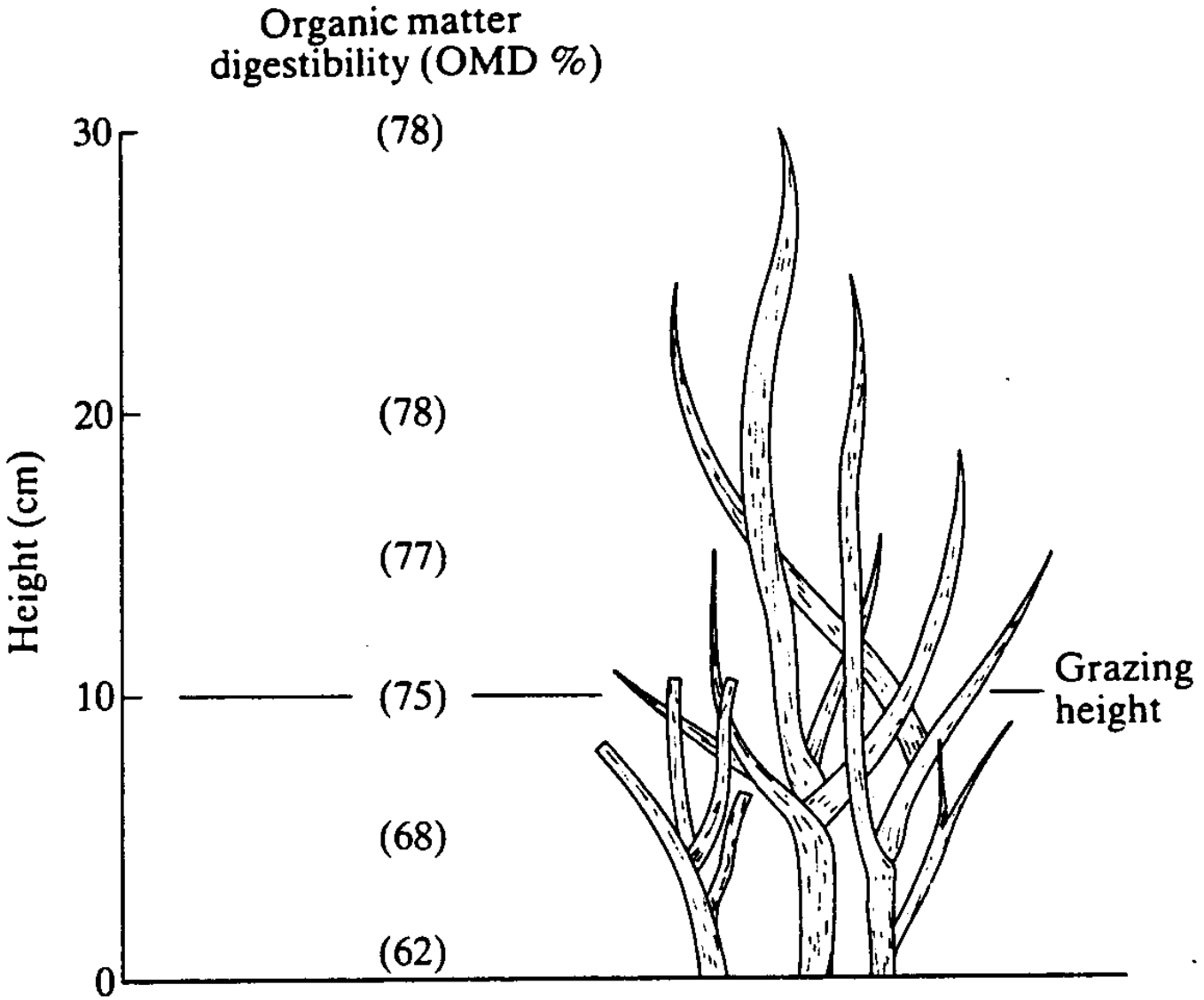
Lipids in forage

- Forages for ruminants:
  - Summer: fresh grass, forbs incl. legumes
  - Plus indoors: silage (grass, maize, other), hay

- Herbage lipids: mostly in green leaves
  Vertical gradient in canopy horizons

- Fatty acid composition of grass:
  mainly unsaturated fatty acids
  (mostly C18:3 also C18:2)

Gradients with canopy height



Sampling, storage, extraction

- Do herbage samples represent ingested feed?
- Easier indoors (offered *minus* refused herbage)
- Grazing animals select:
  - Horizontally: patches, species
  - Vertically: grazed horizons, leaf/stem ratio
- Herbage quality changes during the day
- Animals have diurnal patterns of grazing, rumination and resting
- This hampers precise sampling

Behavior Recorder

Sampling description

- Comparing successive days during 4-D rotational grazing
- Grass was sampled by cutting above 4 cm during morning milking at 40 sites during all 4 days
- Residual grass was sampled after cows were removed from the plot


HALDRUP

Sampling – example from literature

- Comparing successive days during 4-D rotational grazing
- Grass was sampled by cutting above 4 cm during morning milking at 40 sites during all 4 days
- Each day the entire canopy > 4 cm was measured whereas cows would only have eaten the upper layer..
- →FA contents in ingested herbage were in reality probably higher than reported values
- This hampers input-output comparisons

Grazed grass versus cut grass

Four pairs of 2 cows, one grazing and one on cut grass

Daily a new plot with grass for 24 h, change-over design

Similar grass, 20% higher CLA concentration in milk with grazing

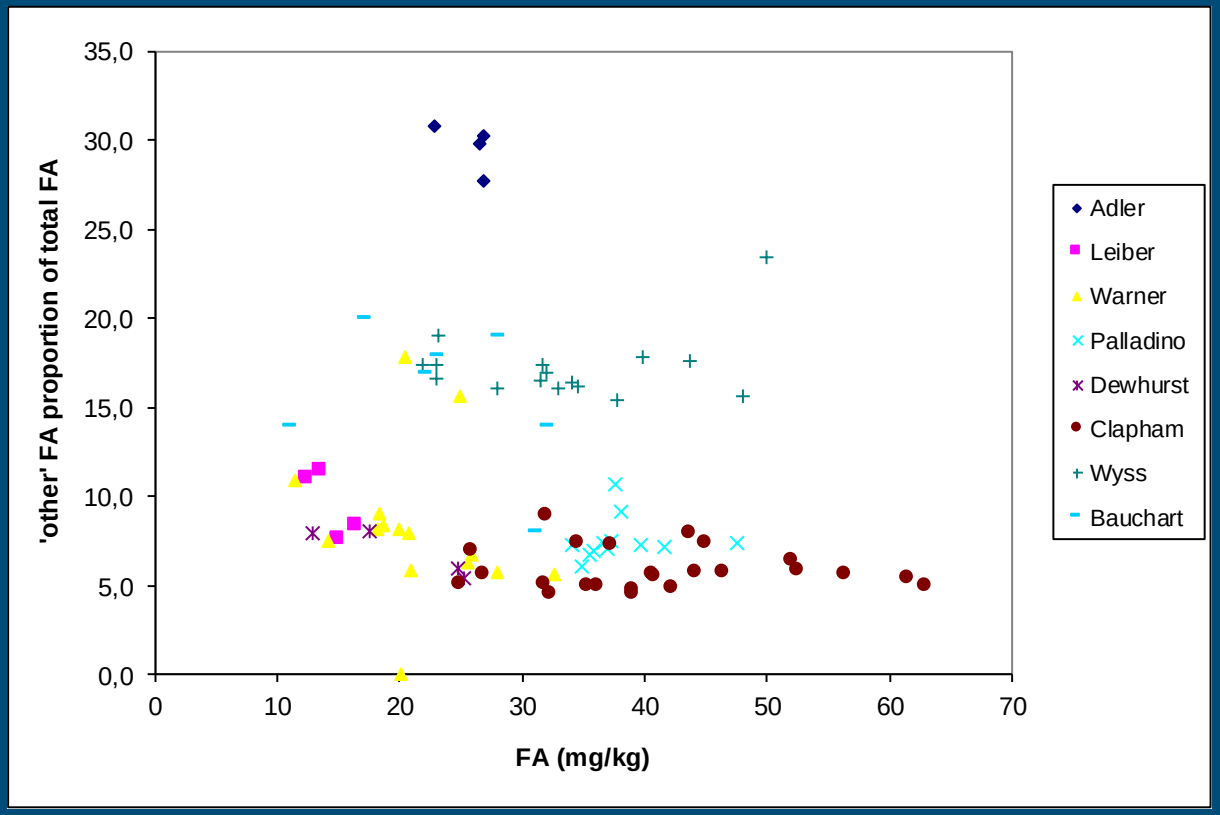
But: more grass residue after grazing, so higher layers were eaten

Storage of samples, extraction

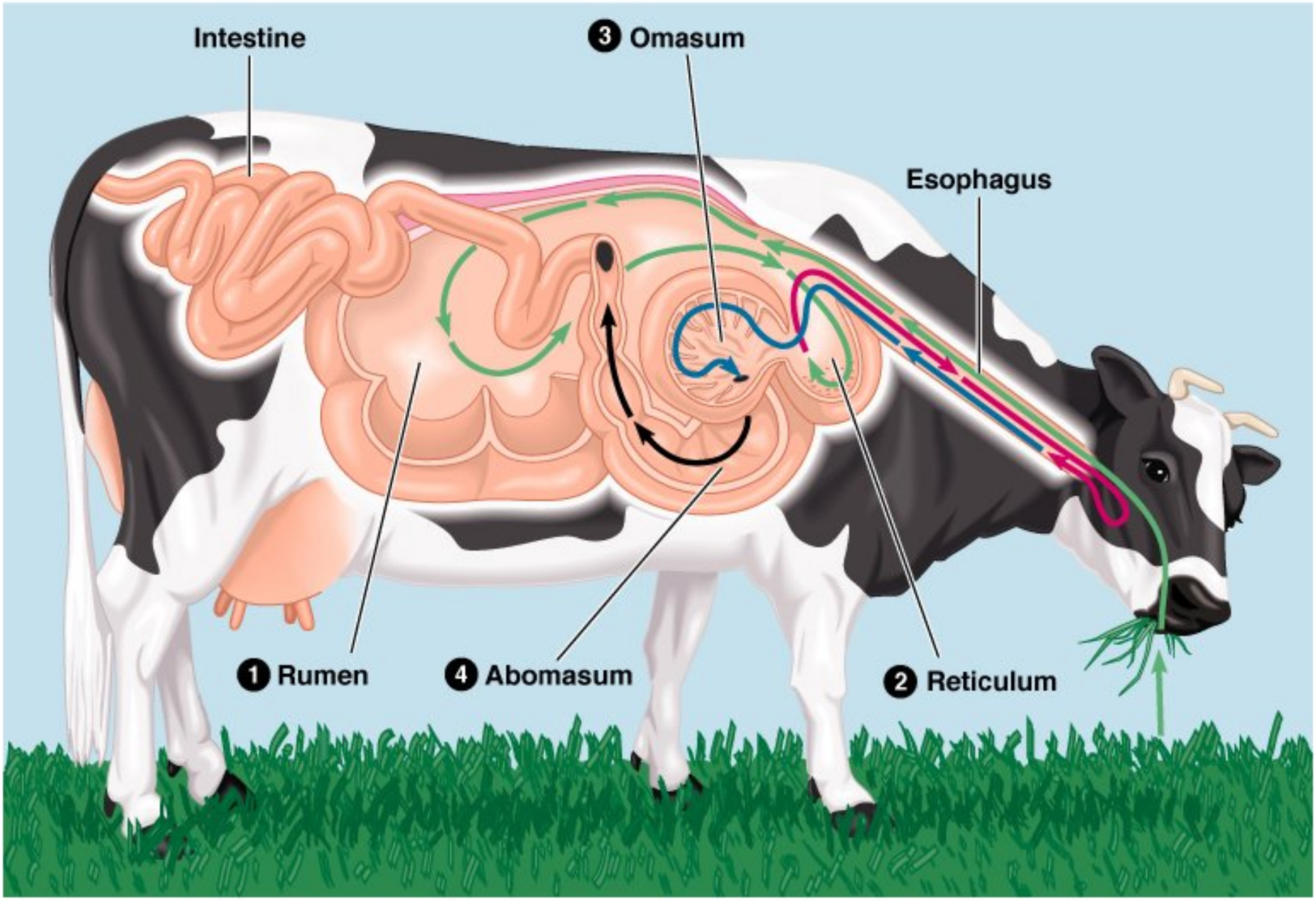
- Mechanical harvest from field or pot
- Time between sampling and cooling
- Time from sampling till arrival in lab
- Direct analysis or Storage – freezing
  - Freezer (-18 ^{o}C)
  - Dry ice (-80 ^{o}C)
  - Liquid nitrogen (-196 ^{o}C)
- Storage duration and temperature
  - Freeze-dried
  - Oven-dried
- Extraction procedures
- →Variation in post-harvest treatment hampers comparison among labs

Analytical methods

‘other FA’ proportions differ among labs

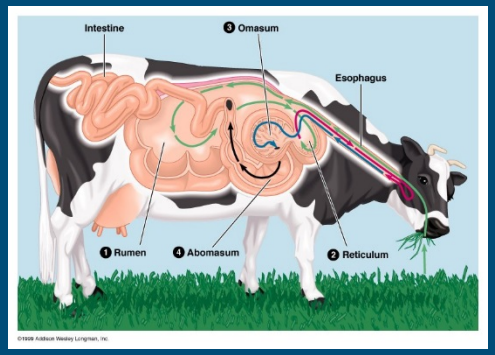


What happens in the field and in the cow?



Processes in grazing animal

- Mechanical harvesting of fresh plant tissue by tongue/mouth
- Chewing and mixing with saliva
- Swallowing and arrival in anaerobic rumen
  - Fermentation by rumen micro-organisms
  - Particle size reduction
  - Regurgitation, chewing and mixing with saliva
  - Further particle size reduction
  - Rumen passage rate
- Exposure to low pH in abomasum
- Passage through intestine
- Exchange of breakdown products with blood
- Transport via blood stream to mammary gland



Sampling herbage and milk

What?

How?

When?

Why?

Milk: be aware that there is a lag phase. Diet of day 1 is reflected in milk of day 2.

Indoor feeding: stable diets

Grazing: changing diets

Compared to stall-fed cows, grazing animals:

Have a more (bio)diverse forage diet

- passage rate of some legumes is faster → less biohydrogenation

- Some herbs have secondary metabolites that may protect PUFA biohydrogenation

→ Higher PUFA transfer from feed to milk

Often no or less silage, less concentrates

Confounding effects

Compared to stall-fed cows, grazing animals:

- Are outside, exposed to sun, rain
- Walk on the grass
- Can express diurnal grazing patterns
- Eat fresh herbage every bite

- →Apart from diet, other factors are confounded.
- This hampers comparisons

Is PUFA transfer from grass to milk fundamentally different with grazing or indoor feeding?

- Challenging question
- Meta-analyses
- PUFA intake quantification:
  - Herbage intake
  - Contents of FA in ingested feed (herbage)
- Under grazing, measurements are more difficult
- Methodological constraints with sampling
- Analytical methods in different studies / labs

Thank you for your attention

Thanks to EAAP for the opportunity to present this work today

Contact and more info:

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