SUSTAINABLE MILK PRODUCTION AND THE IMPACT ON MILK QUALITY AND FUNCTIONALITY

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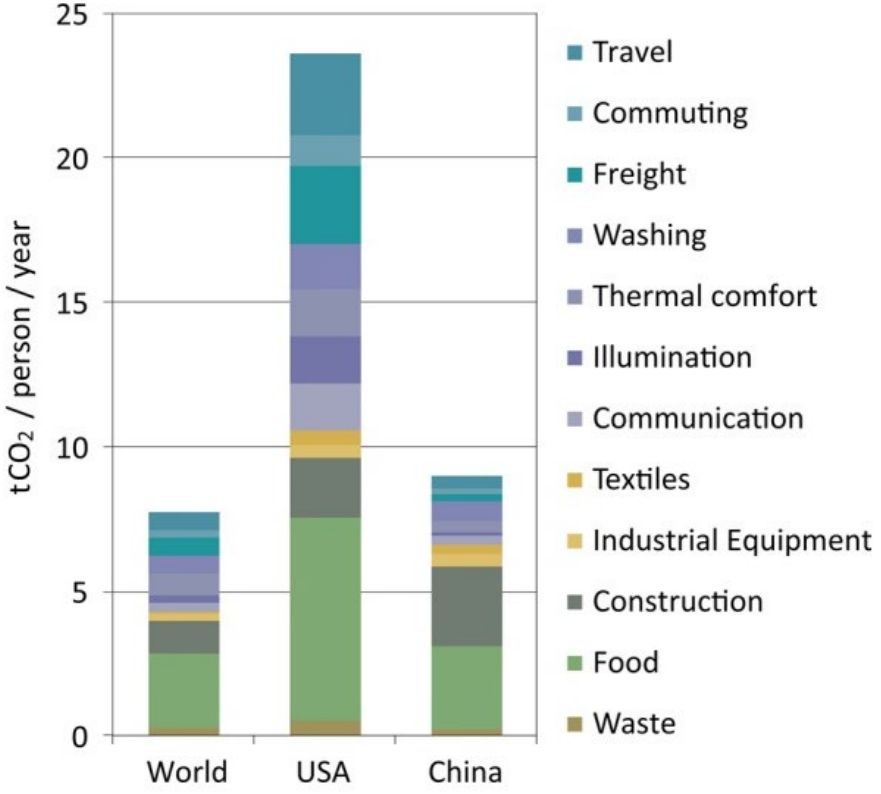
DEPARTMENT OF FOOD SCIENCE

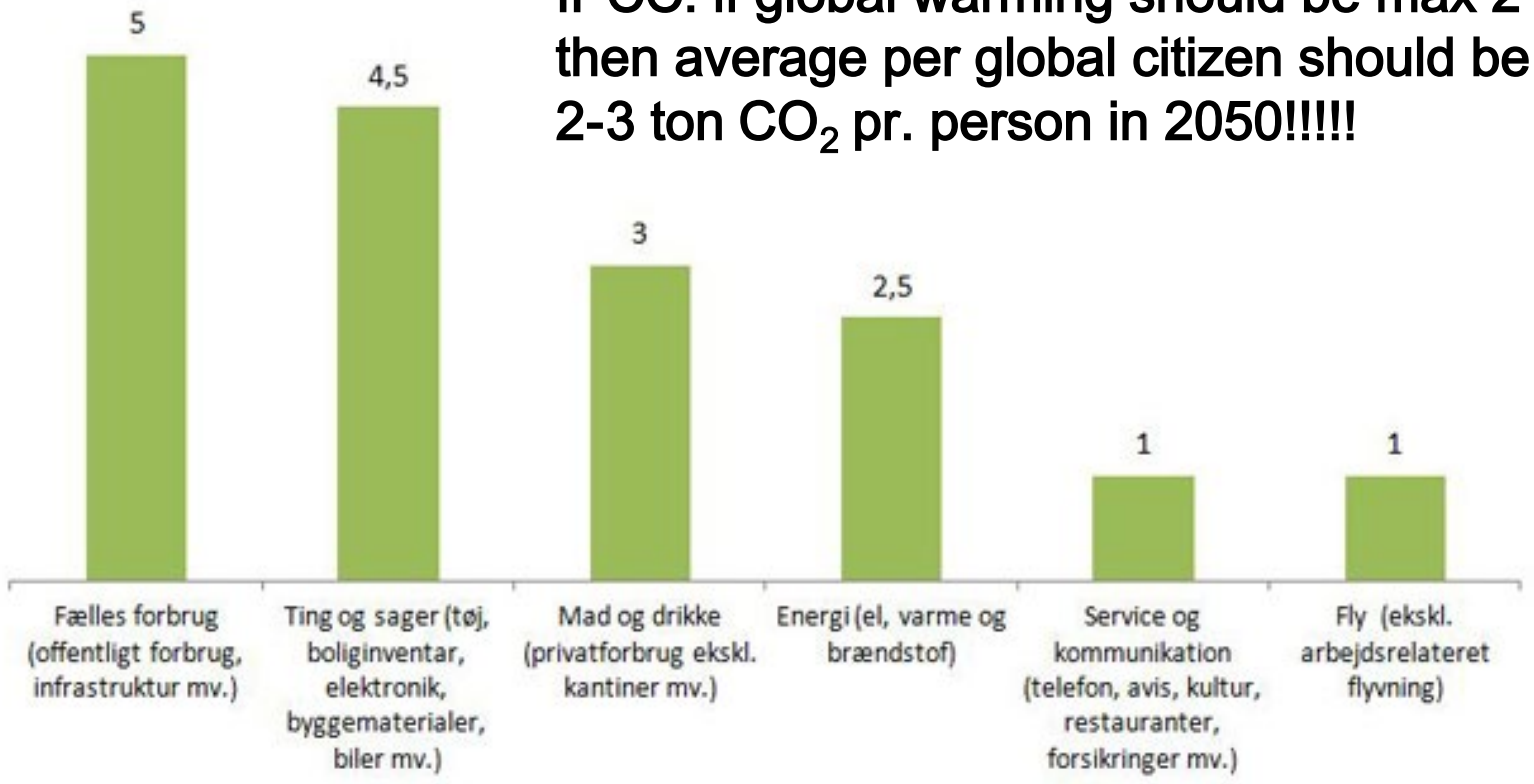
AVERAGE EMISSIONS PER PERSON



Bajzelj et al. 2013

Average: 17 tons CO_2e per Dane
Food and drinks: 3 tons (18 %)

IPCC: if global warming should be max 2°C, then average per global citizen should be 2-3 ton CO_2 pr. person in 2050!!!!!



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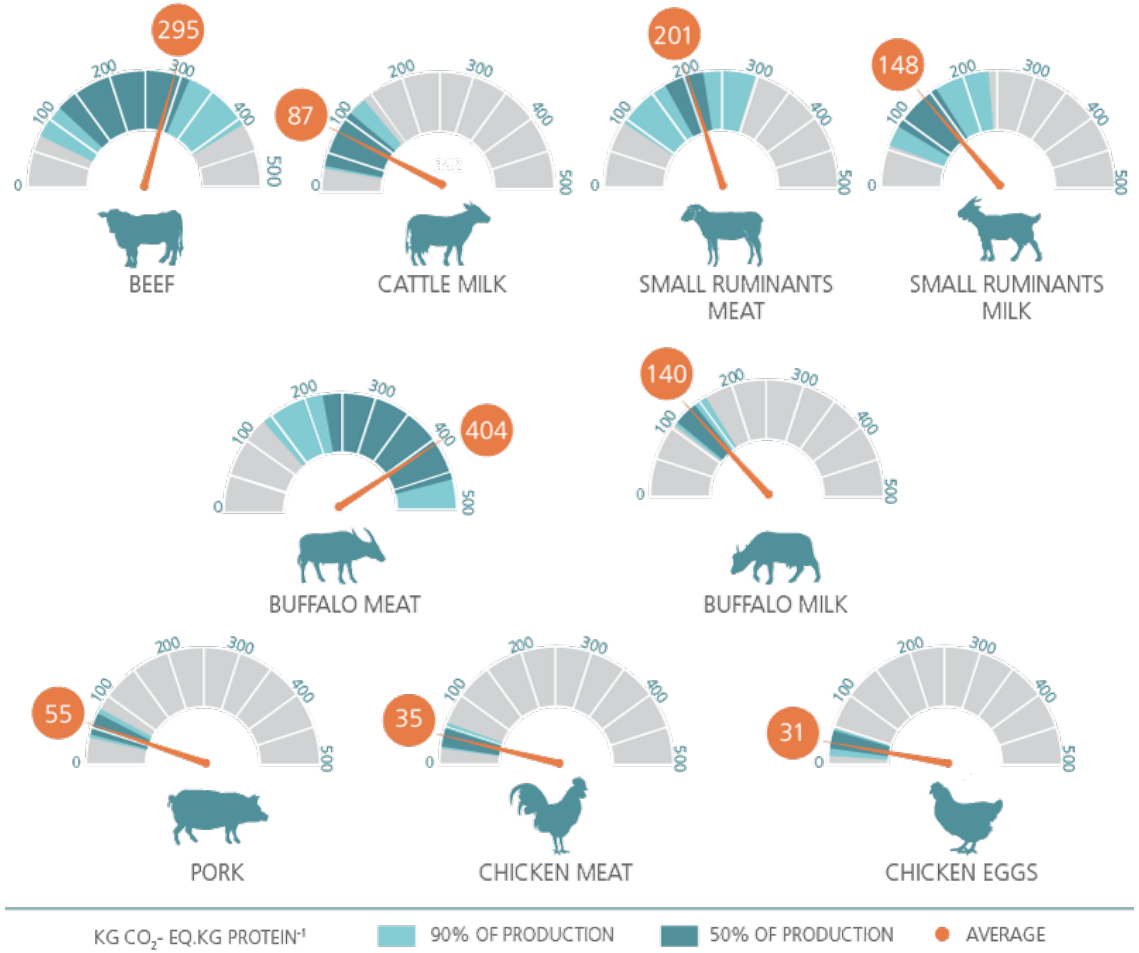
CONCITO
DANMARKS GRØNNE TÆNKETANK

IS THERE A FUTURE FOR MILK AND DAIRY?

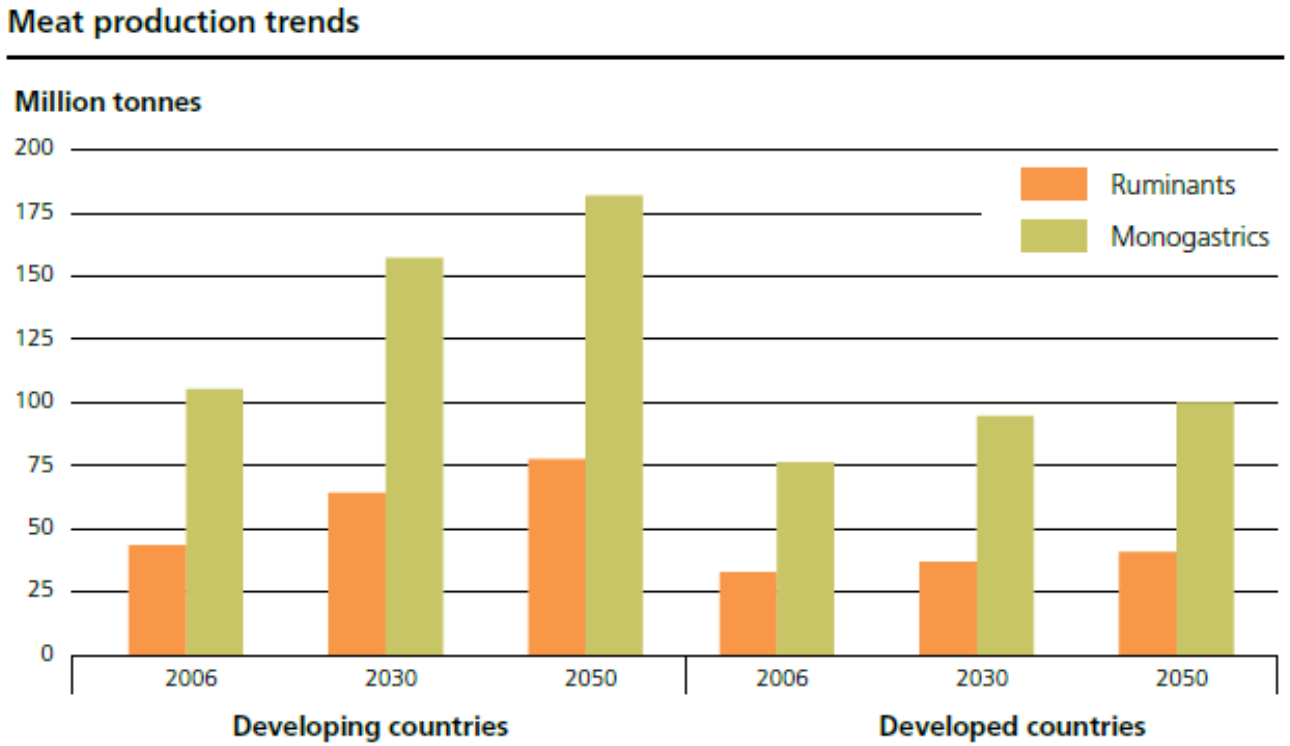
EAT LANCET report, graphics by Videnskab.dk



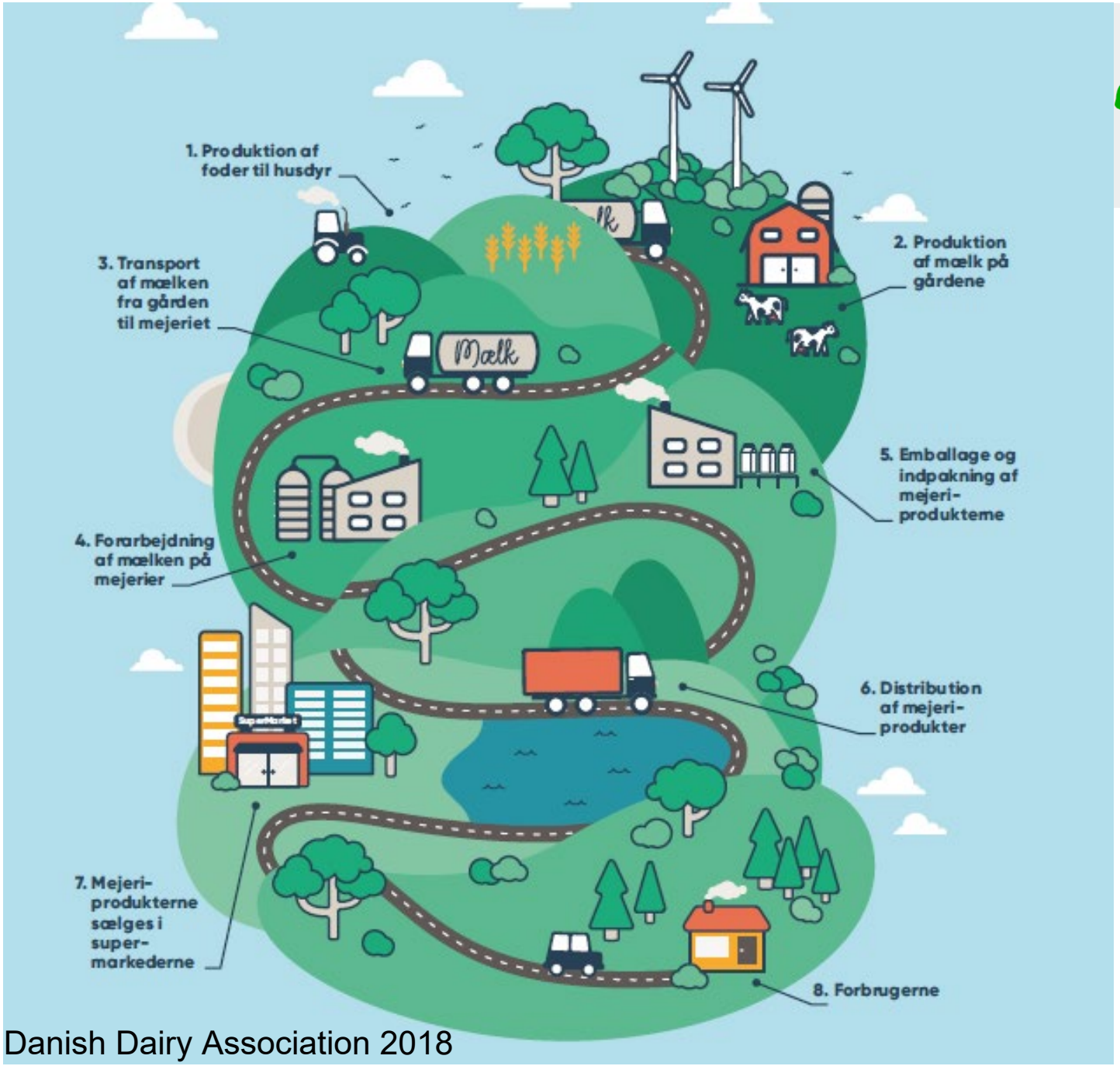
Global Livestock Environmental Assessment Model, FAO

FUTUREDEMANDS

Demand for milk in developing countries is predicted to increase by 46 percent by 2050 and demand for meat by 76 percent!!



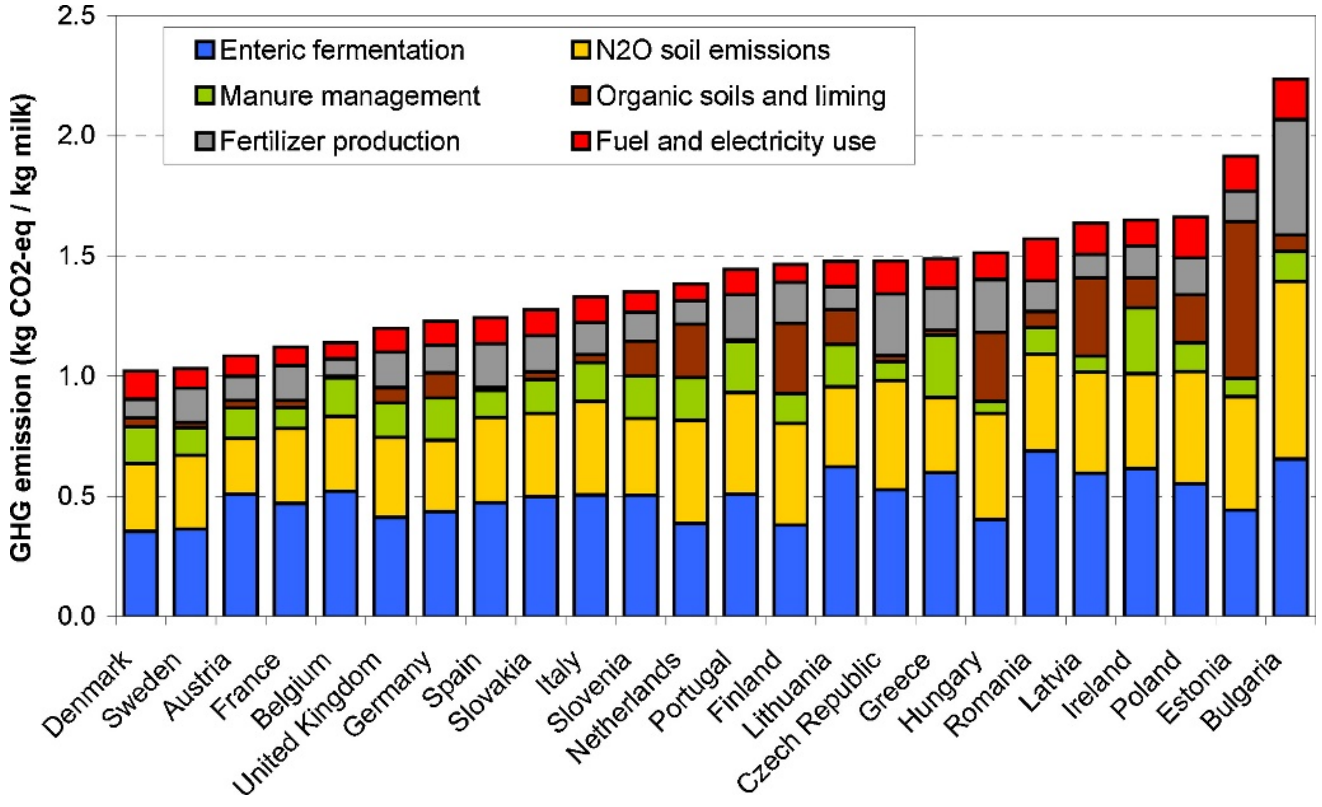
FAO



Danish Dairy Association 2018

Global Livestock Environmental Assessment Model, FAC

EU-27 GHG EMISSIONS FOR MILK PRODUCTION

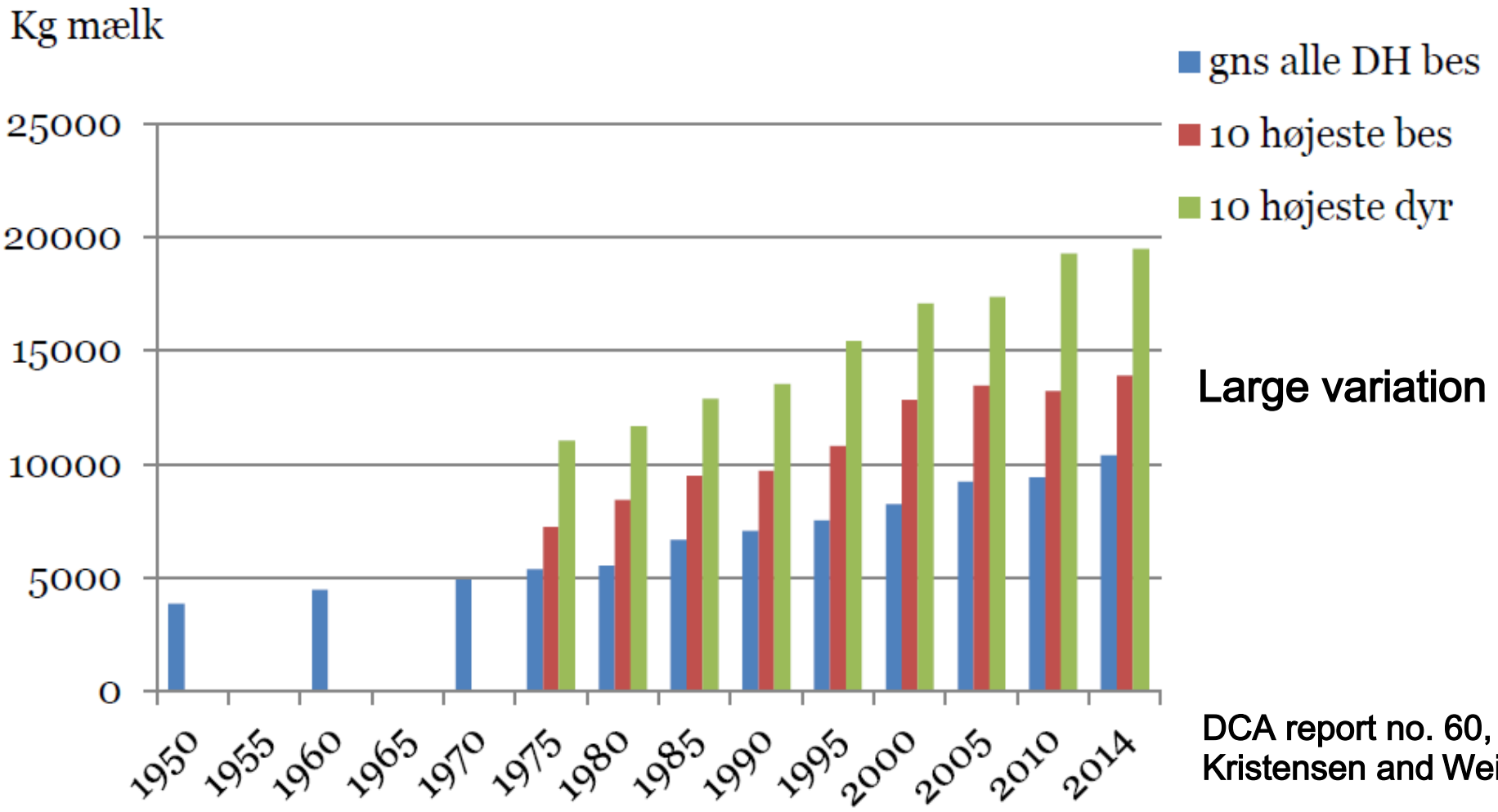


Lesschen et al. (2011)

Within EU-27: large variations in GHG emissions per kg milk

In 2008; EU-27 produced 26% of world's milk

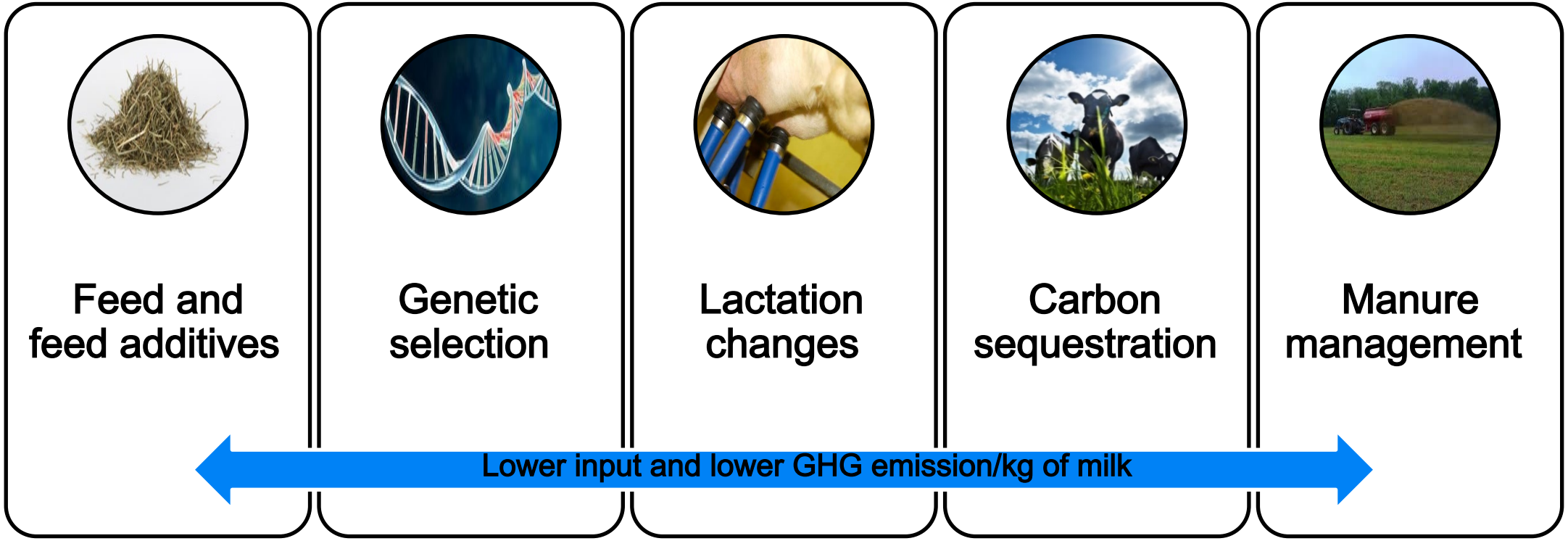
MILK PRODUCTION DK HOLSTEIN FARMS



Large variation between farms and animals

DCA report no. 60, 2015
Kristensen and Weisbjerg

MITIGATING STRATEGIES



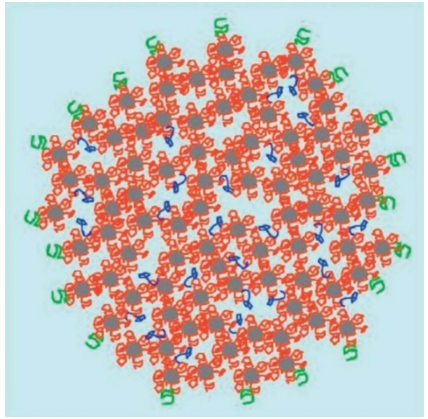
- Not one-size-fits-all
- Short-term and long-term effects
- Should not compromise animal welfare and milk quality

HUMAN NUTRITION – BOVINE MILK

Nutrient	% daily coverage by ½ L 3.5% milk (female 31-60 years)
Energy	15
Protein	22
Fat	23
Vitamin A	22
Vitamin D	5
Vitamin B2	**72**
Vitamin B12	**113**
Calcium	**73**
Magnesium	20
Phosphorous	**78**

Larsen et al., (internal report)

EFFECTON FUNCTIONALPROPERTIES



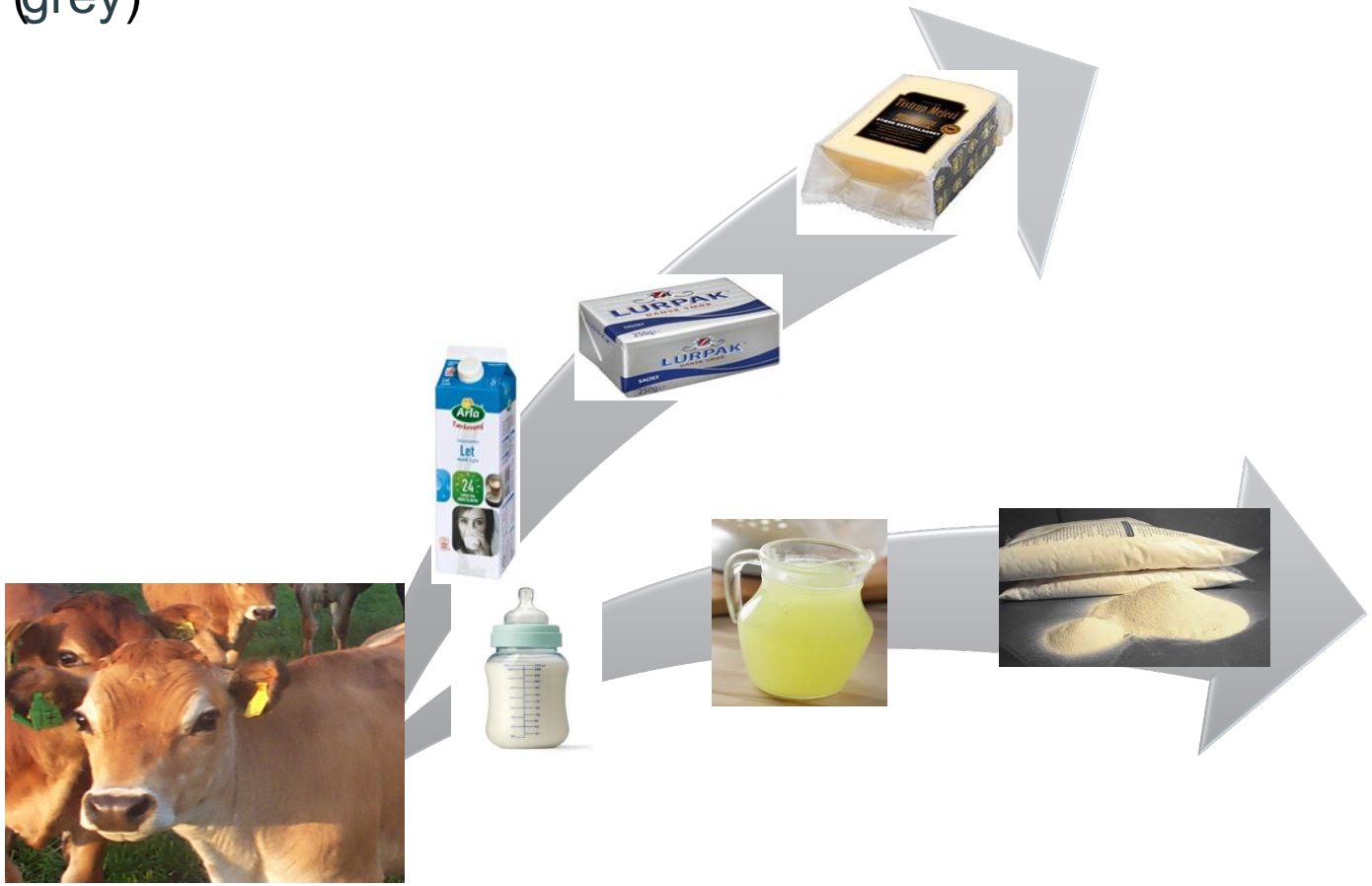
Dalgleish (2011)

CaP nanoclusters (grey)

α-caseins (red)

κ-casein (green)

β-casein (blue)



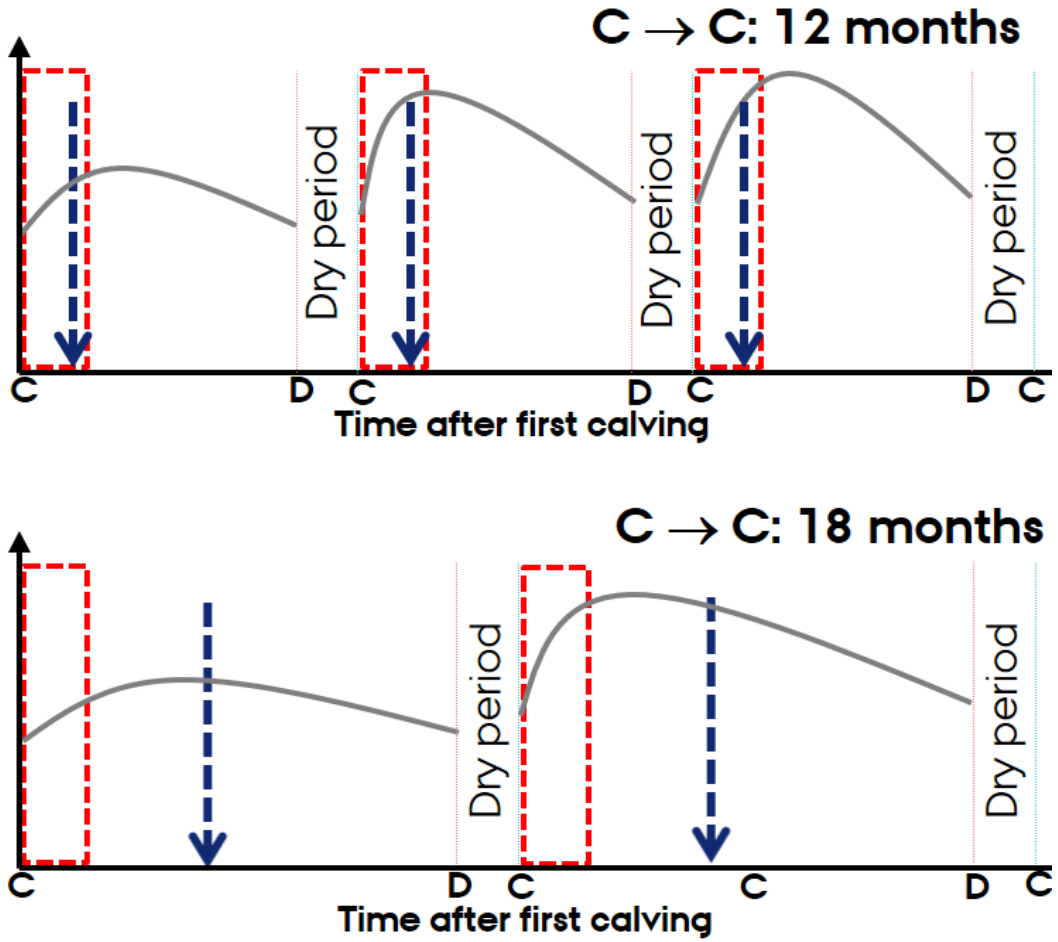
EXTENDED LACTATION

Delaying re-breeding and emphasizing management to maximize the persistency of lactation

C → C: Calving interval
C → D: Lactation period
D → C: Dry period

Re-breeding

Critical period!
High risk of diseases
Failure to re-breed



Guilherme de Moura Maciel 2017, Adapted from Knight (2005). *Adv. Dairy Techn.*, *17*, 113–123

GOOD MILK QUALITY

Changes due to pregnancy

Fra **180 ⇨ 90 DBC**:

▲Protein, %

▲Casein, %

▲Casein:protein ratio, %

▲CFR, G'max

▲ Curd yield

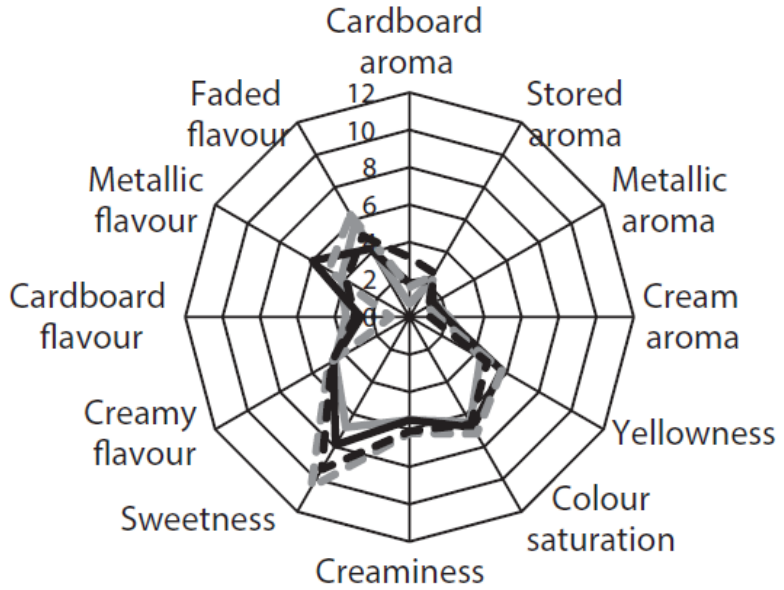
15 ⇨ 18-mo **calving interval:**

— Protein, %

— Casein, %

— Casein:protein ratio, %

No significant changes

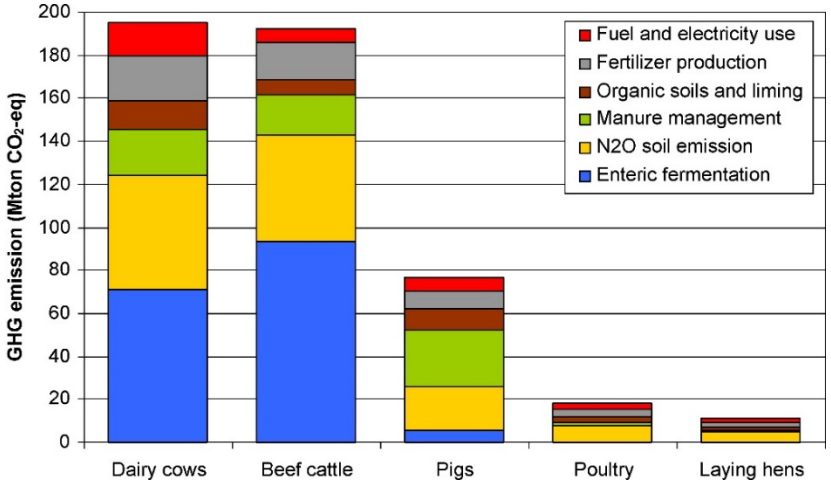


No sensory demerits of the milk

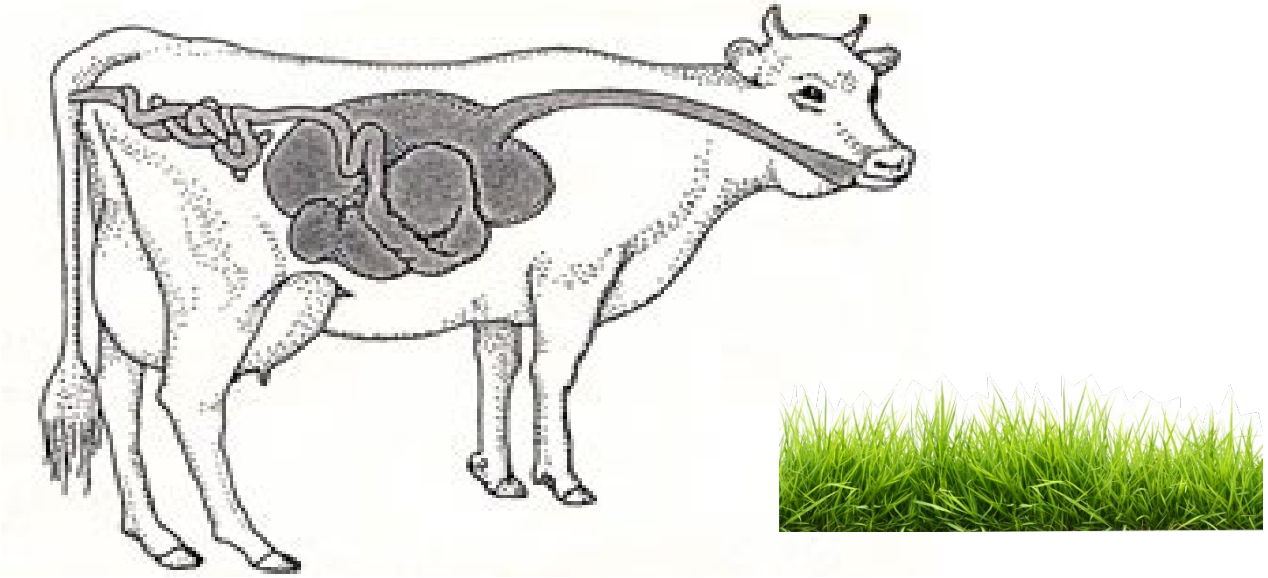
No concerns in relation to milk quality

Maciel et al. 2016, Journal of Dairy Science 99:8524-8535; Maciel et al. 2017, International Dairy Journal 70:2-11

ENTERIC FERMENTATION



Lesschenet al. (2011)



Carbohydrate fermentation to volatile fatty acids (VFA):

$C_6H_{12}O_6 + 2H_2O \rightarrow 2CH_3COOH + 2CO_2 + \mathbf{4H_2}$ **acetic acid**

$C_6H_{12}O_6 + \mathbf{2H_2} \rightarrow 2CH_3CH_2COOH + 2H_2O$ **propionic acid**

$C_6H_{12}O_6 \rightarrow CH_3CH_2CH_2COOH + 2CO_2 + \mathbf{2H_2}$ **butyric acid**

Gas	Relative climate effect
CO_2	1
CH_4	34
N_2O	290

Hydrogen surplus reacts with CO_2 and eliminated through belching as methane:

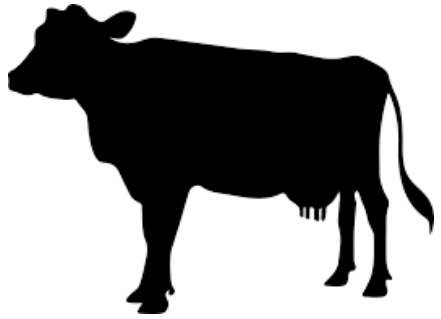
$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$ **methane**

EFFECT OF FEED CHANGES AND FEED ADDITIVES ON MILK QUALITY AND FUNCTIONALITY

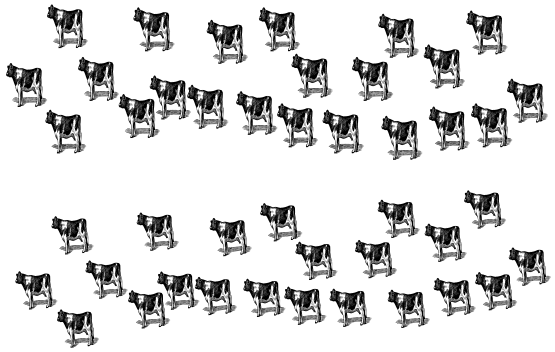
Feeding

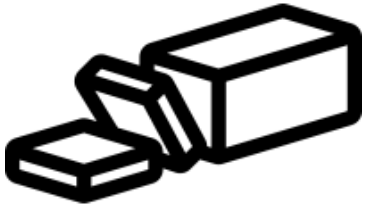
Feed additives
3-NOP
Nitrate
Component X
Others

Animal feeding trials



Farm testing

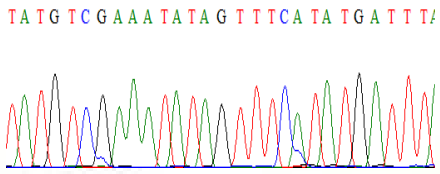




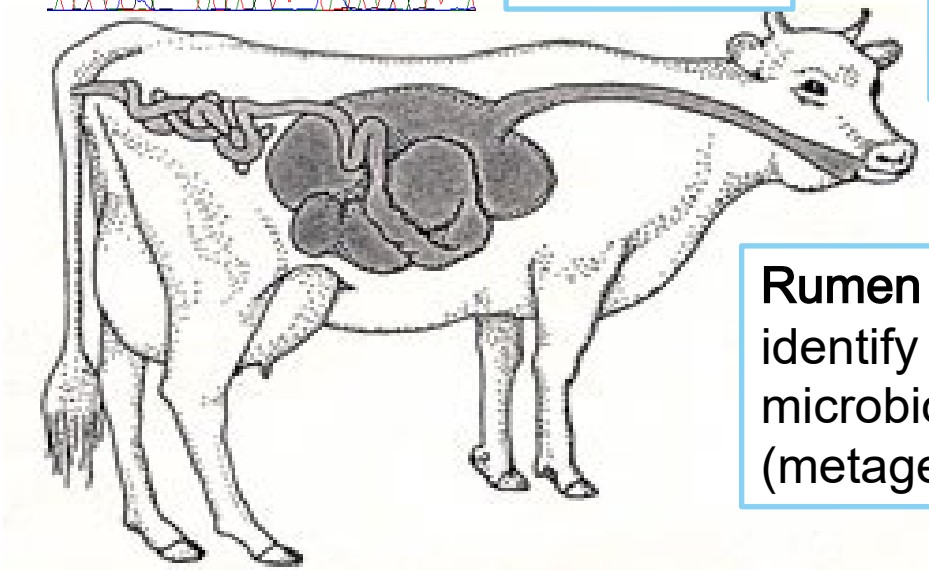
METHANE MEASUREMENTS

Photo credits: Aarhus University

EFFECT OF THE METAGENOME



DNA sample



Breath sample
CH_4 and CO_2

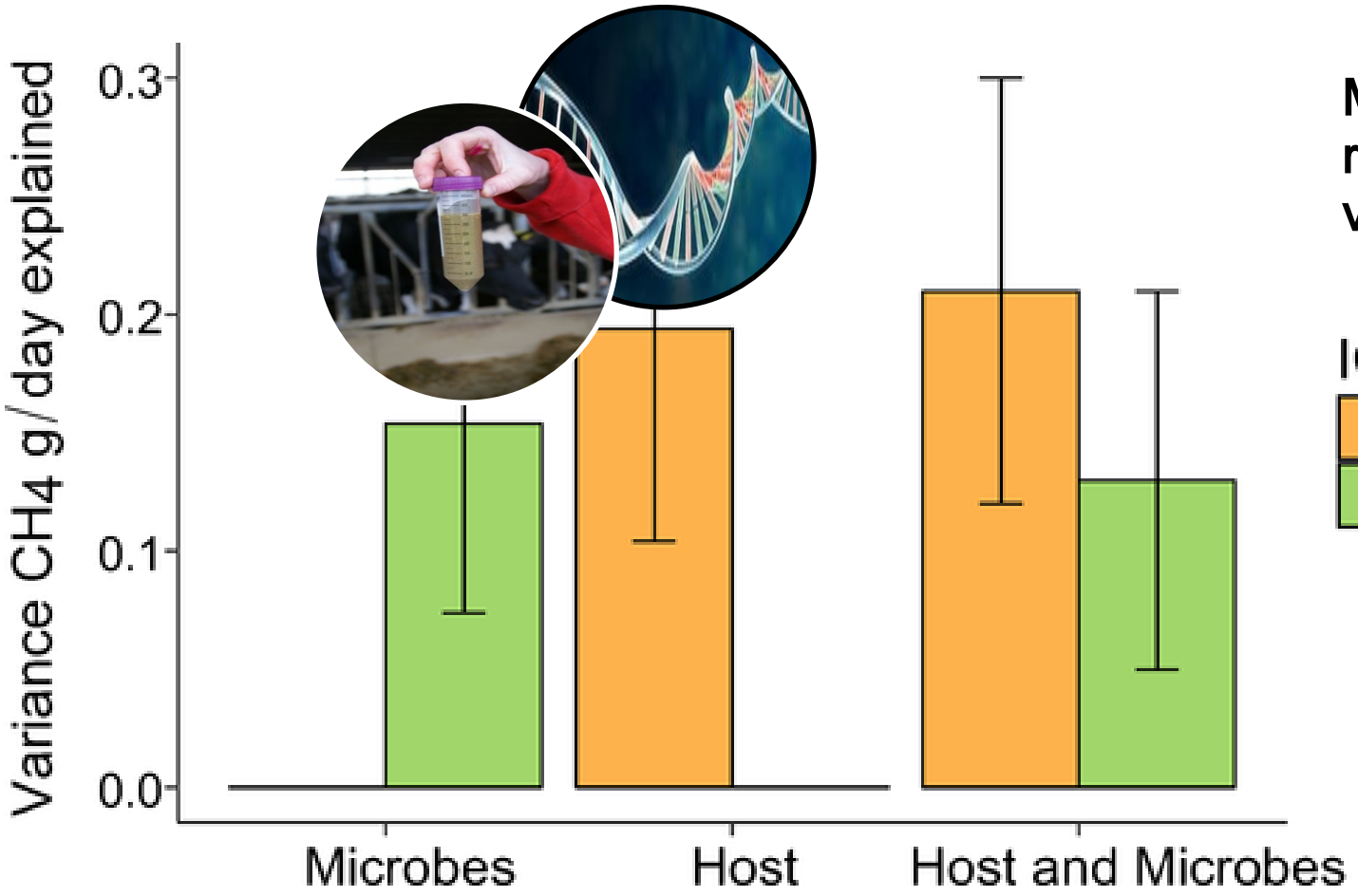
Rumen sample
identify rumen microbiome (metagenome)

Milk sample

Fatty acid composition, protein profile, Metabolites, vitamins and FTIR

Project funded by Milk Levy Fund
Partners: AU-FOOD and AU-MBG

EFFECT OF THE GENOME AND METAGENOME ON CH_4 EMISSION



Microbial abundance + genetic effects responsible for 34% of total phenotypic variation in CH_4 emissions

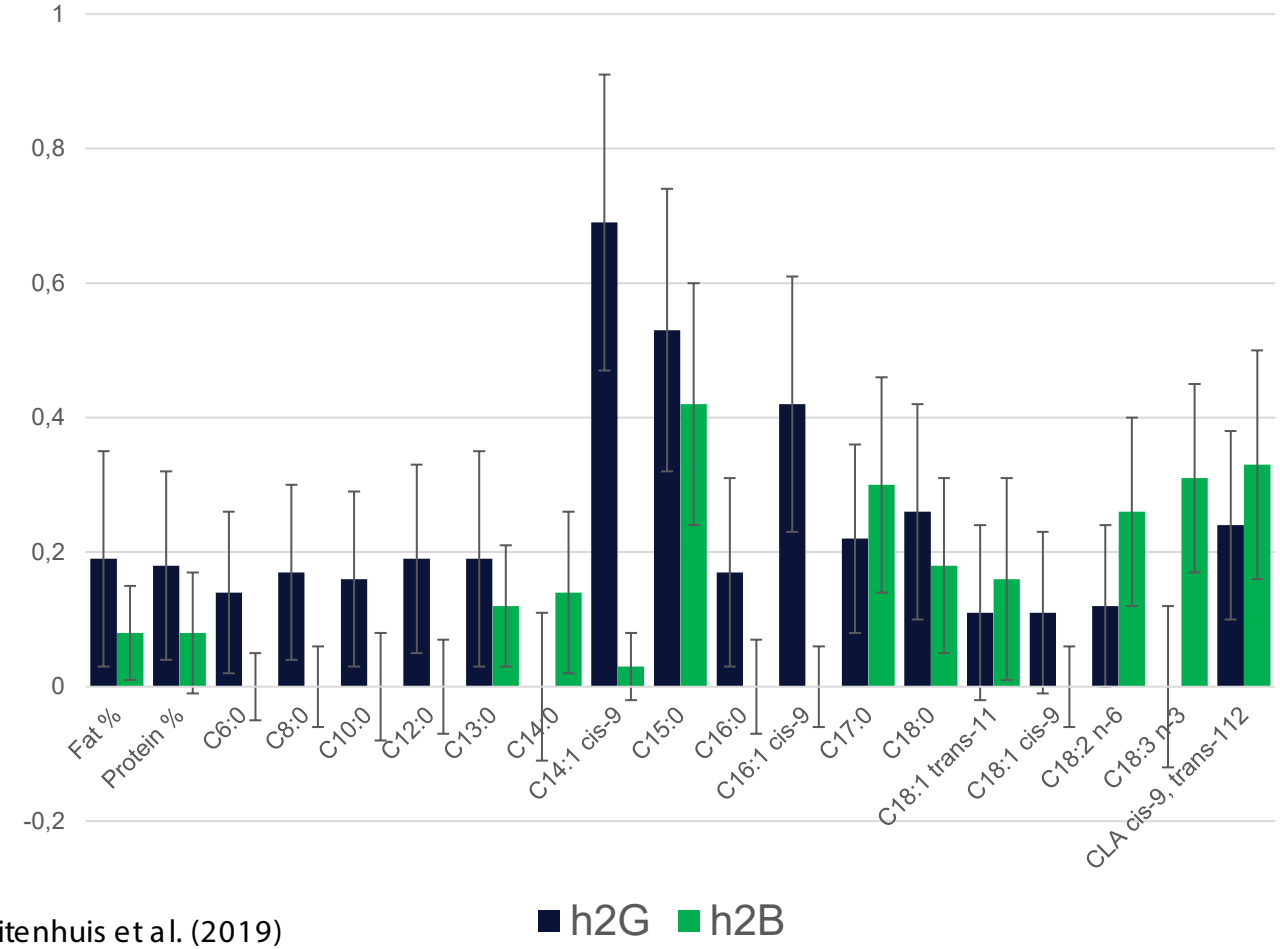
ICC

heritability $= h^2_G = 0.19$

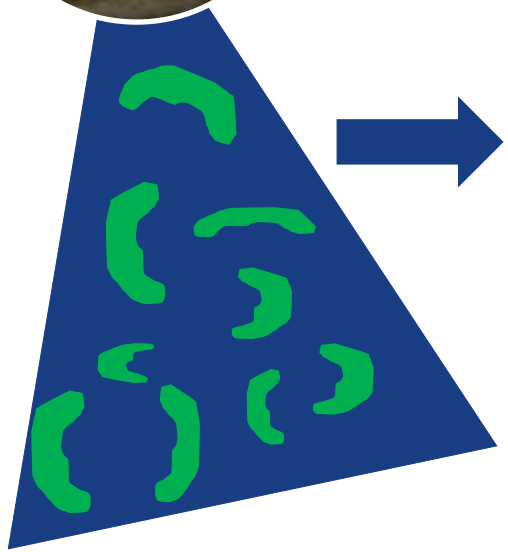
microbiability $= h^2_M = 0.15$

Difford et al. (2018) Host genetics and the rumen microbiome jointly associate with methane emissions in dairy cows. PLOS Genetics 14(10)

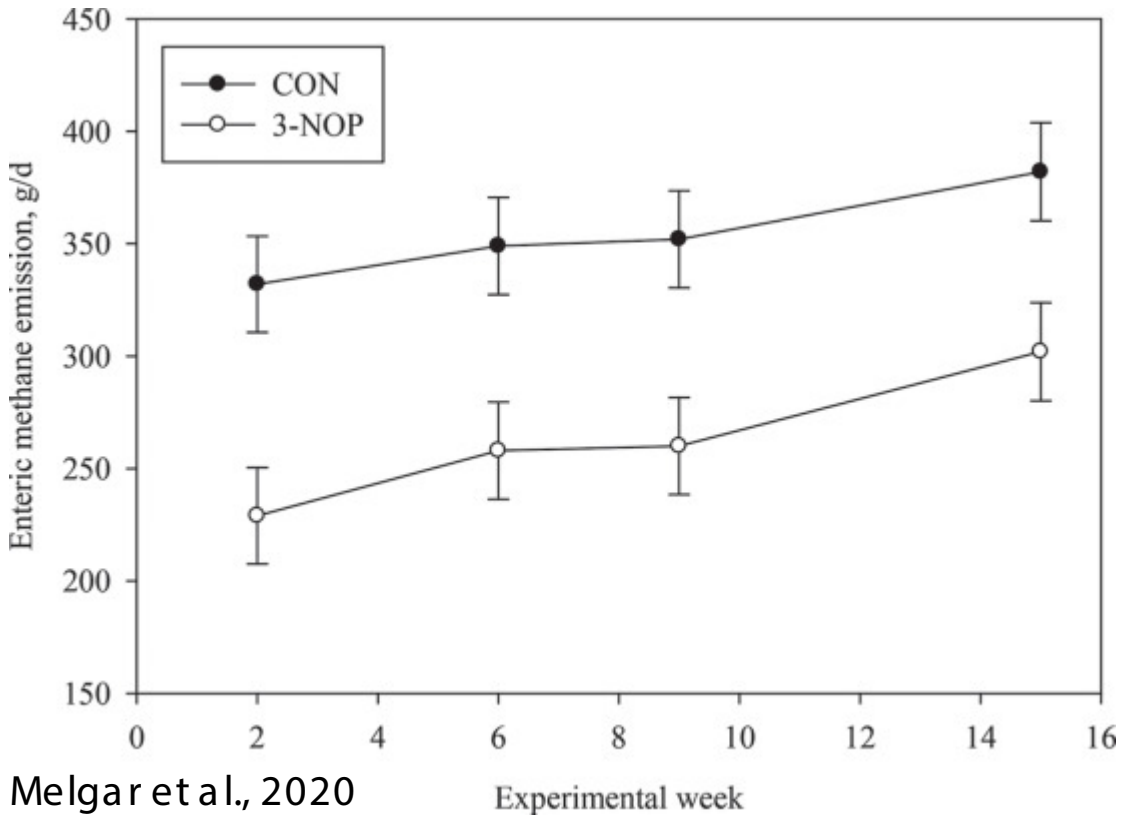
EFFECT OF THE METAGENOME AND GENOME ON FATTY ACIDS



Buitenhuis et al. (2019)



FEED ADDITIVES – EXAMPLE 3-NOP



Melgar et al., 2020

Compared with control diet, 3-NOP decreased daily CH_4 emission by 26%

KLIMA

Ko nummer 8489 er bøfelskeres og mælkedrikkeres store håb

”Det seneste projekt, som ko 8489 har været med i, er netop blevet færdig. Ved at tilsætte det hollandske middel Bovaer plus noget nitrat og fedt til foderet er det lykkedes forskerne at reducere metanudslippet fra køerne med 40 procent.”

Professor Peter Lund, AU DR.DK May 10, 2021

NITROGEN AND PHOSPHOR EXCRETION

Reduced P excretion

Protein-rich concentrate:

soy, rapeseed, horsebeans

± phytase

Reduced N excretion

Differences in forage:

TMR with 60% forage

grass:corn silage ratio

Feed intake
Feed composition

Excretion of N and P to manure and urine

Transfer of N and P to milk and effect on milk quality

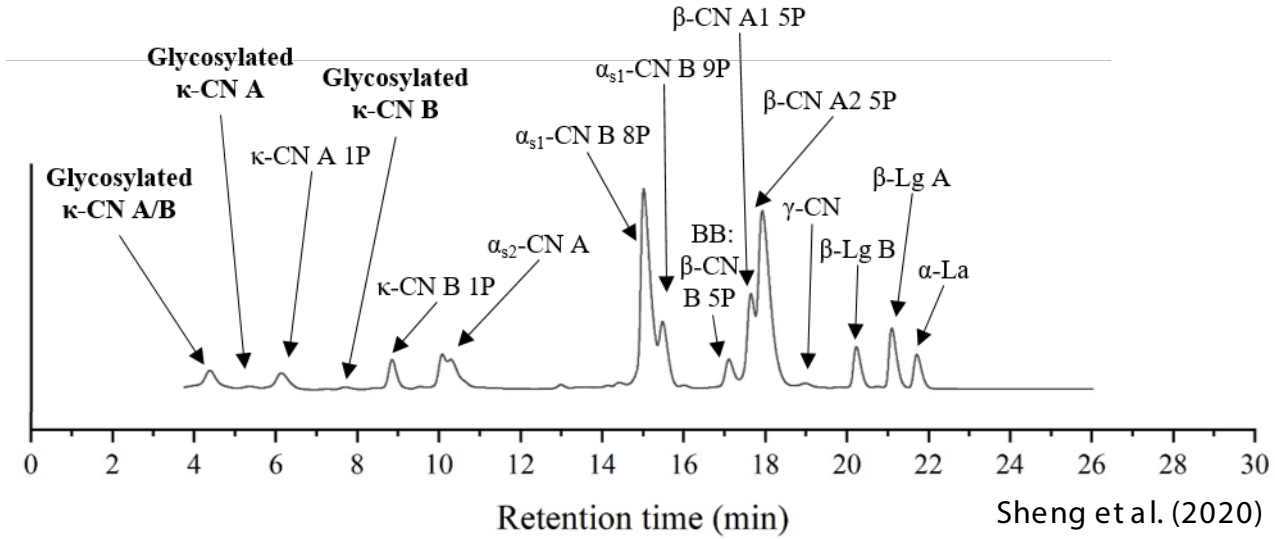
Fatty acid composition
Protein profile, micelle size
Minerals and calcium distribution, Ethanol stability
FT-IR

Project funded by Milk Levy Fund, Partners: AU-FOOD, AU-ANIS, RYK and AU-MBG

EFFECT ON MILK PROTEIN COMPOSITION

Trait	P-value		
	CM	EN	LS
α_{S1}-CN (%)	NS	NS	NS
α_{S1}-CN 8P (%)	NS	NS	0.04
α_{S1}-CN 9P (%)	<0.001	NS	0.13
PD %	<0.001	NS	0.08
α_{S2}-CN (%)	NS	NS	NS
β-CN (%)	NS	NS	NS
κ-CN %	NS	NS	NS
G κ-CN %	NS	NS	NS
UG κ-CN %	<0.001	NS	NS
GD %	0.01	NS	NS
α-LA %	NS	0.02	0.02
β-LG %	NS	NS	NS

Poulsen et al., 2021, JDS, accepted



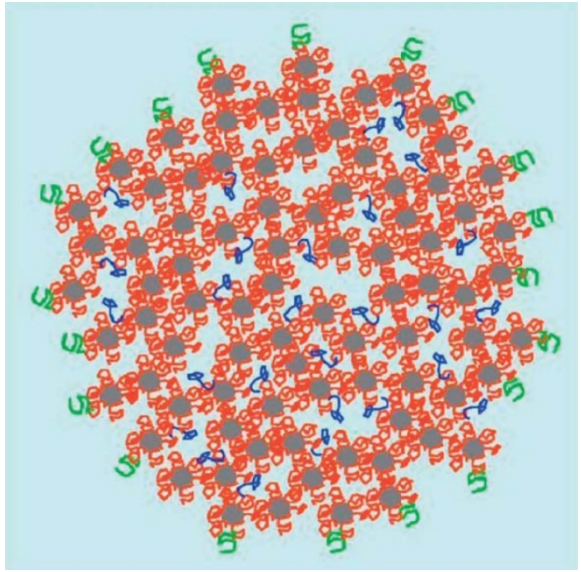
Sheng et al. (2020)

- Lower CP intake in cows fed FAV compared to cows fed RSM and SBM (3.74 vs 4.06 kg/d)
- Cows fed FAV had lower milk protein% compared to cows fed SBM and RSM (3.62 vs 3.74 and 3.71%, $P < 0.01$

Feed protein source significantly affected :

- α_{S1}-CN 9P%,unglycosylated κ-CN%
- Phosphorylation degree of α_{S1}-CN (PD)
- Glycosylation degree of κ-CN (GD)

EFFECTOF FEEDON FUNCTIONALPROPERTIES



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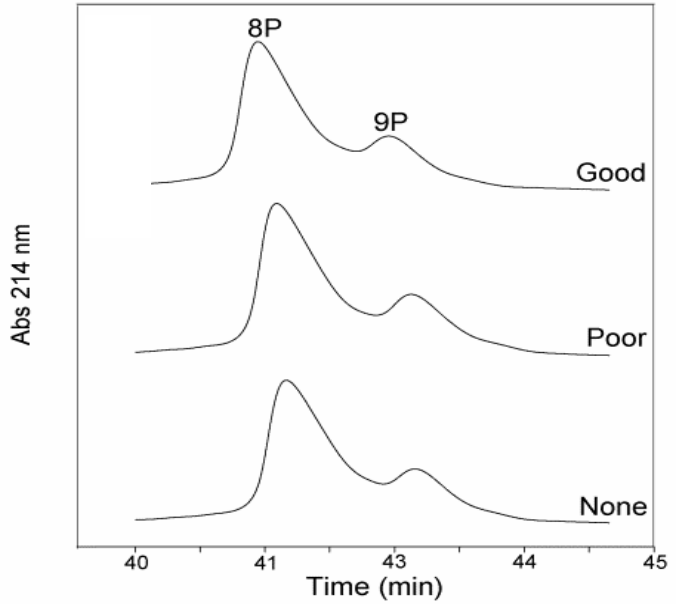
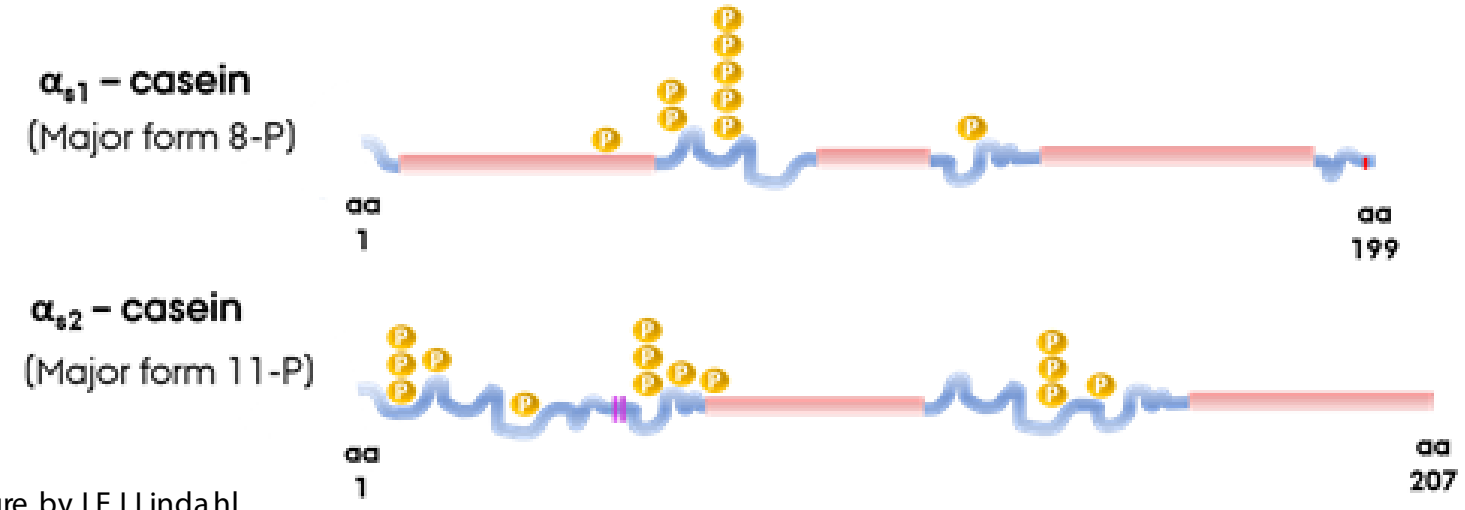




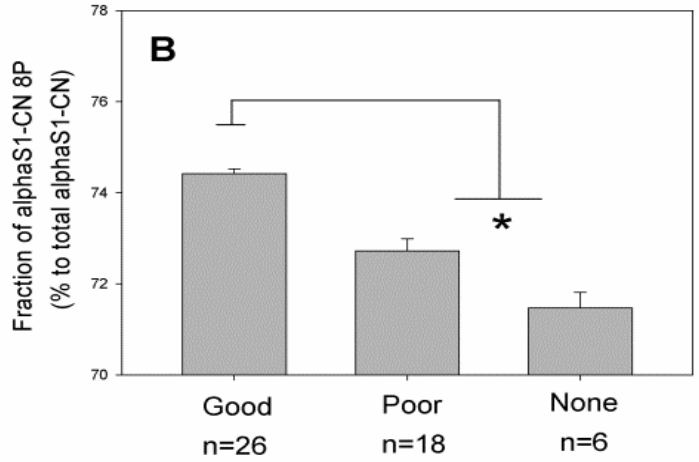
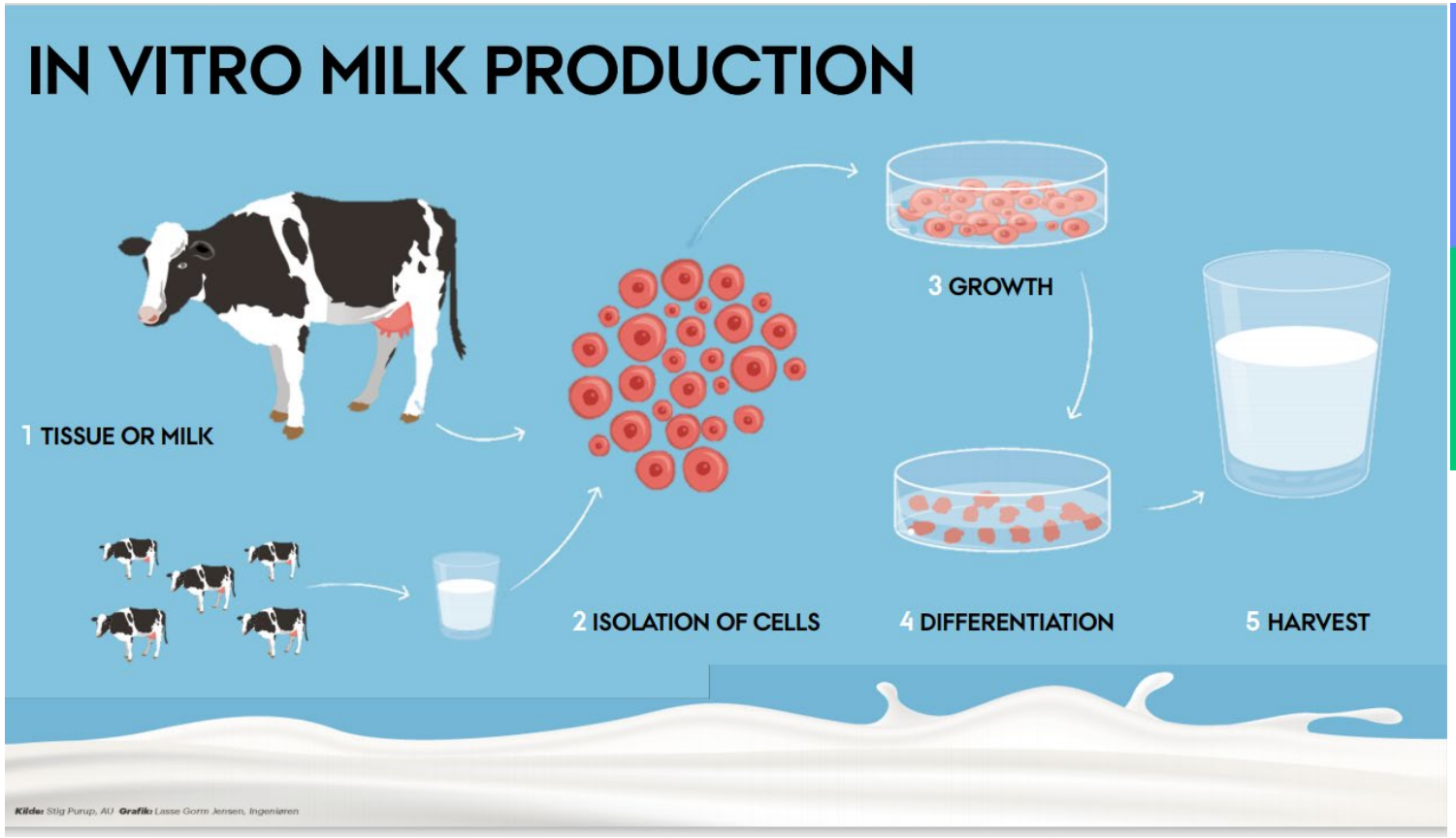


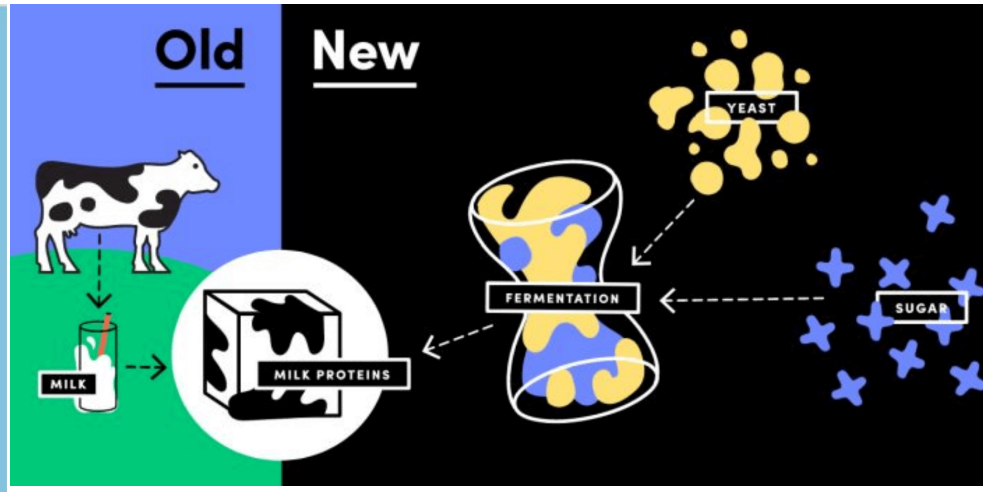
Figure by I.E.I Lindahl

Jensen et al., 2012

IS THERE A FUTURE FOR MILK?



Kilde: Stig Purup, AU; Grafik: Lasse Gorm Jensen, Ingeniøren



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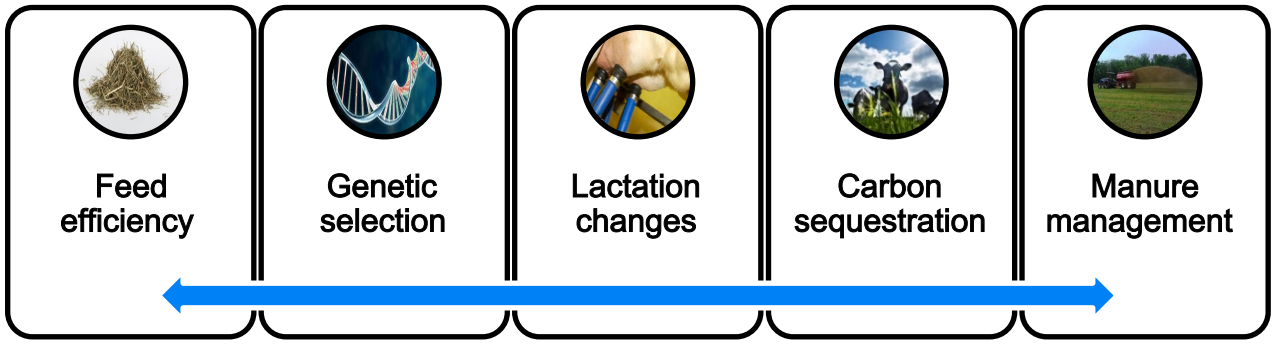
CONCLUDING REMARKS

3 GOOD HEALTH AND WELL-BEING

”Dairy products are a part of healthy, affordable and sustainable diets”

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

”Dairy converts inedible plant material into high-value food”



Dairy in support of the Sustainable Development Goals

The Asian Dairy Sector is strongly positioned to help reach the Sustainable Development Goals. However, there are still challenges that we must overcome.

THANKYOU