AARHUS UNIVERSITY

EFFECT OF FEED RATION ON MILK PRODUCTION, MILK QUALITY AND SUSTAINABILITY

METTE KROGH LARSEN
TROELS KRISTENSEN
SØREN KROGH JENSEN
MARLENE RANSBORG PEDERSEN
GRITH MORTENSEN
MARTIN RIIS WEISBJERG

AARHUS UNIVERSITY
DEPARTMENT OF FOOD SCIENCE

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

AARHUS UNIVERSITY
DEPARTMENT OF ANIMAL SCIENCE

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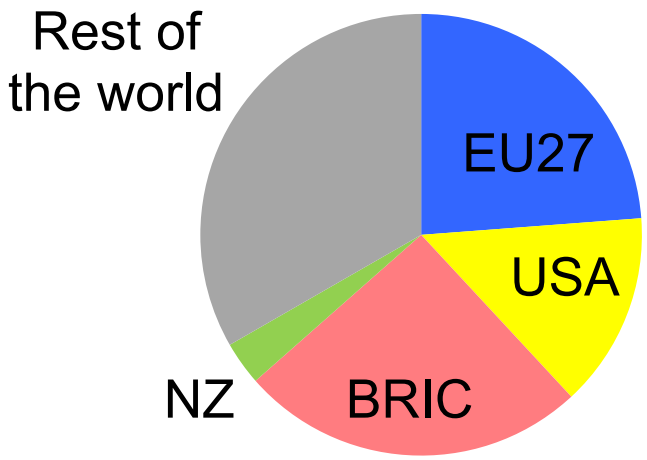
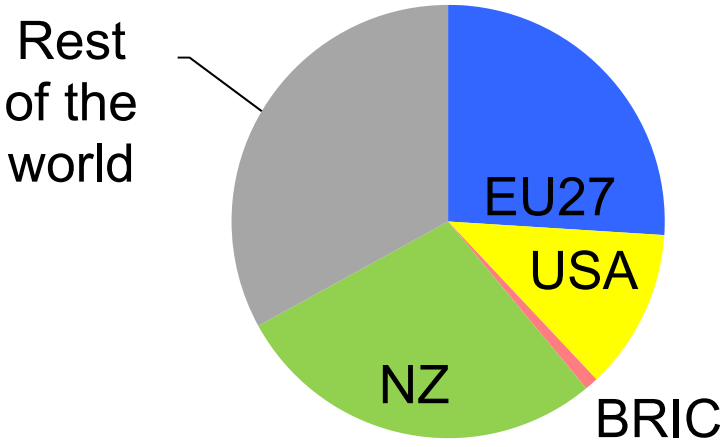
WORLD BOVINE MILK PRODUCTION

Total 640 Mt

% of world production



% of world export



IDF, 2013

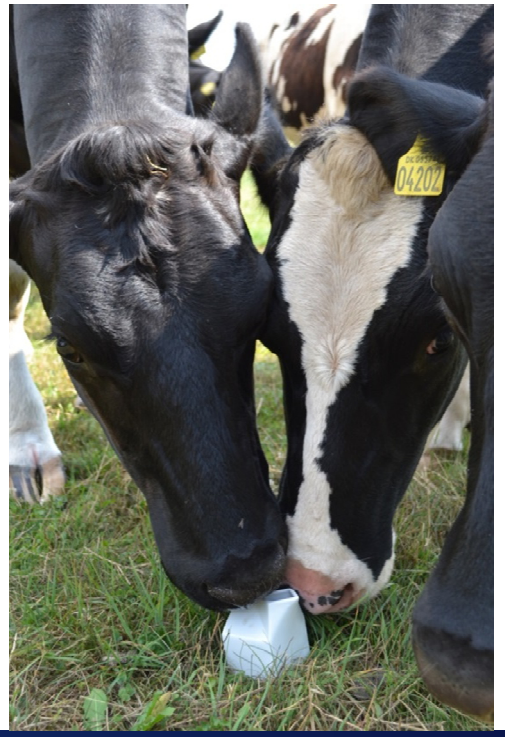
OUTLINE OF PRESENTATION

Feed Composition

Milk composition & Quality

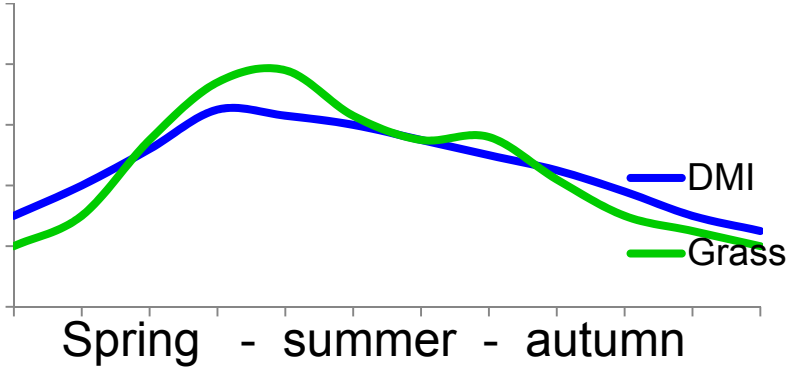
Milk production and sustainablity

Perspectives in development
of new milk types



PRODUCTION SYSTEMS

- Low intensity
- Grazing natural grasslands
- Spring calving



- High intensity
- TMR feeding
- Loose housing
- All year calving

FEEDING

- Forages

- Pasture grass
- Conserved forage
- Grass, legumes, herbs
- Whole crop
- Beets

- Concentrates

- Cereal grains
- By products
  - Sugar
  - Oil
  - Biofuel
- Legume seeds

FEED NUTRIENT SUPPLY

- Forage
  - NDF
  - Sugars
  - Protein
  - Starch
  - Fatty Acids
  - Vitamins & Antioxidants
- Concentrate
  - Starch
  - Protein
  - Fat

RUMINANT NUTRIENT SUPPLY

- Nutrients in feed
  - Carbohydrates
  - Protein
  - Fat
- Nutrients absorbed
  - VFA, microbial matter, glucose
  - Microbial protein, rumen undegraded protein
  - Hydrogenated FA (partly), microbial FA

FEEDING AND MILK GROSS COMPOSITION

	Protein %	Fat %
Increased energy intake Increased conc./forage ratio	↑	(↓)
Increased NDF	↓	↑
Increased sugar	(↑)	↑
Increased protein	(↑)	
Undersupply EAA	↓	↓
Increased FA	↓	↑↓

MILK IN HUMAN NUTRITION

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**

Foodcomp.dk & NNR2012

VITAMINS IN MILK

Vitamin	Content in milk	Sources of variation
Vitamin A (µg/L)	300-500	B-carotene from grass etc
Vitamin D3 (ng/L)	60-270	Sun exposure, vit. suppl
Vitamin E (mg/L)	0.4-1.2	Grass etc, vit. suppl
Vitamin B2 (mg/L)	0.7-2.8	Ruminal synthesis, feed
Vitamin B12 (µg/L)	1-13	Ruminal synthesis

MINERALS IN MILK

Mineral	Content in milk	Sources of variation
Calcium (mg/kg)	1000-1300	Genetics, protein
Magnesium (mg/kg)	100-150	Genetics, protein
Phosphorous (mg/kg)	900-1000	Genetics, protein
Iodine (µg/kg)	20-200	Feed, rapeseed ↓
Zinc (µg/kg)	700-5000	Feed
Selenium (µg/kg)	10-20	Feed

MILK FATTY ACIDS

Fatty acid	% of milk FA	Human relevance	Source
C4-C14	10-20	Positive, at least C4-C10	De novo
C16:0	22-45	Negative	Feed & De novo
C18:0	6-12	Neutral	Feed
MUFA	15-30	Positive	Feed + desaturase
PUFA	2-5	Positive	Feed
C18:3 n3	0.2-1.5	Positive	Grass; Linseed
CLA c9tr11	0.3-1.5	Positive	PUFA; Grass

DAIRY PRODUCTS

Product	Important properties	
Liquid fresh milk	Flavour Colour	
Fermented milk products		Viscosity
Cheese		Milk coagulation, texture
Butter		Texture
Milk powder		

Flavour includes oxidative stability

FLAVOUR OF MILK

Flavour characteristic	Source	Reason	Feed
Rancid	FFA	Mechanical /large fat globules/high milk fat	
Cardboard/ Metal	Oxidation	Imbalance pro/antioxidants and PUFA	High PUFA Low antioxidants
Barny	Skatole	Ruminal formation at high protein + high sugar in feed	Clover grazing
Cornflakes			Maize silage
Fresh flavour	Volatiles from feed transferred to milk		Aromatic feed (herbs)

DAIRY PRODUCTS AND FEED

Product	Property	Reason	Feed
Butter/cheese/ powder/cream	Yellow	High carotenoid	Grass feeding Jersey cows
Butter	Soft (spreadable)	High UFA	UFA from feed
Butter, Cheese	Firm	Low UFA	Low fat or high C16
Mature cheese	Textural properties	Differences in plasmin/ plasminogen activity	Botanical composition of grassland
Cheese	Late bloats	Anaerobic spores	Poor quality silage

SUSTAINABILITY

- **Biodiversity**
- **Land use**
- Nutrient use
- Climate impact
- **GHG emission**

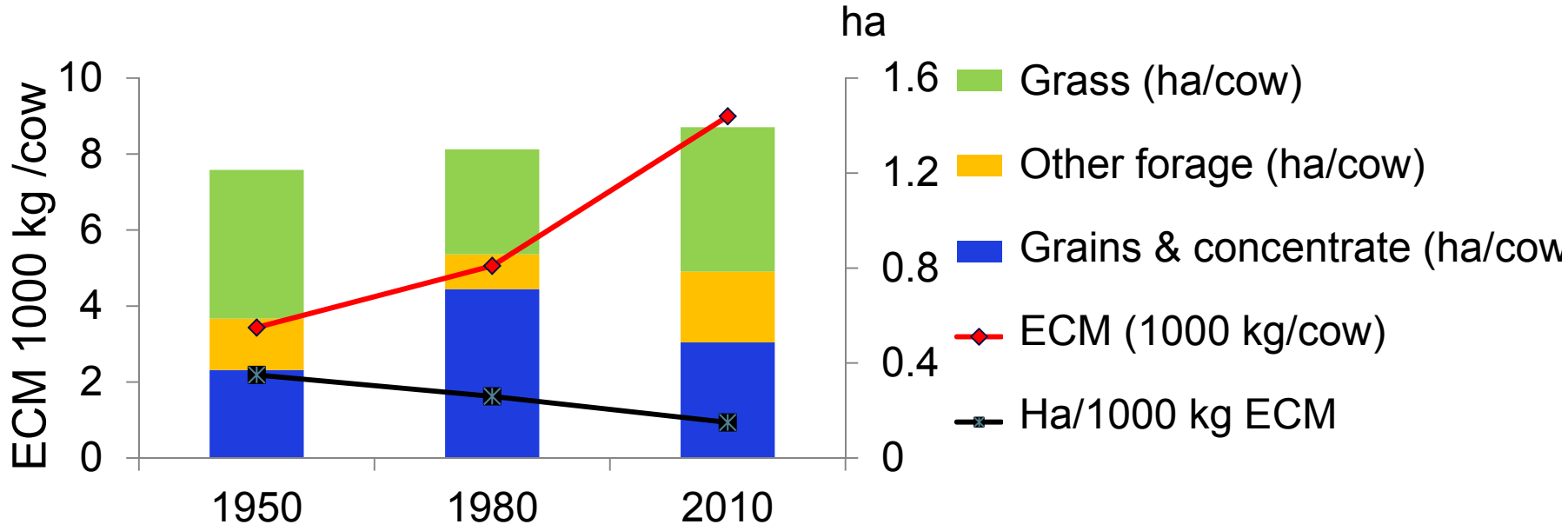
BIODIVERSITY

High biodiversity:

- Organic farming
- High proportion of grassland
- Grazing grass opposed to mowing

LAND USE

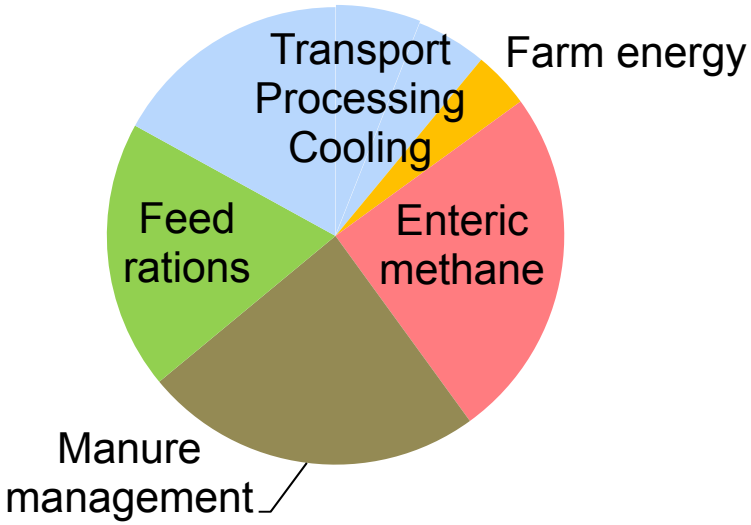
Development in Danish milk yield and land use



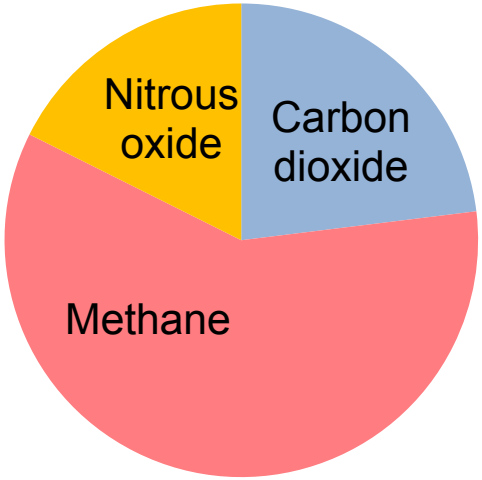
Kristensen, 2014

GHG EMISSION

2.05 kg CO_2 eq
kg milk consumed



Farm GHG emission



Mod. from Thoma et al, 2013

METHANE EMISSION

Methane production (/kg milk) can be reduced by:

- Increase concentrate to forage ratio
- Increase maize silage to grass silage ratio
- Include fat supplements

- CO_2 release from land use not included

High kg milk/kg DMI = High efficiency → reduction in GHG/kg milk

PERSPECTIVES

- Increase
  - Feed efficiency
  - Vitamins
  - Cheese yield
  - PUFA
  - Biodiversity
- Decrease
  - Feed costs
  - Saturated fat
  - Risk of off-flavour
  - GHG emission
  - Land use

SCENARIOS FOR FUTURE MILK TYPES

Reference TMR feeding:

- 60% forage: maize silage and grass silage in equal amounts
- 40% concentrate: cereal grains and oil seed meals

MAIZE MILK

Milk production based on >50% DMI from maize silage

Production		**Milk composition**		**Dairy products**		**Sustainability**	
Yield		Vitamins	↓	Butter	Pale	Land use	↓
Fat%		SFA		Cheese	Pale	Biodiversity	↓
Protein%	↑	PUFA	↓	Milk powder		GHG	↓
		Flavour	sweet	Yoghurt	viscous		

PASTURE MILK

Milk production based on >40% DMI from grazing high yielding clover grass

Production		**Milk composition**		**Dairy products**		**Sustainability**	
Yield	(↓)	Vitamins	↑	Butter	Yellow soft	Land use	↑
Fat%		SFA		Cheese	yellow	Biodiversity	↑
Protein%		PUFA	↑	Milk powder		GHG	
		Flavour	barn	Yoghurt			

BIODIVERSITY MILK

Milk production based on grazing natural grassland

Production		**Milk composition**		**Dairy products**		**Sustainability**	
Yield	↓↓	Vitamins	↑	Butter	Yellow Soft	Land use	(↑)
Fat%		SFA	↓	Cheese	Yellow Texture	Biodiversity	↑
Protein%	↓	PUFA	↑	Milk powder		GHG	↑
		Flavour		Yoghurt	Less viscous		

PROTEIN MILK

Production of milk with an increased protein%:

- High concentrate, high starch, less fat

Production		**Milk composition**		**Dairy products**		**Sustainability**	
Yield	↑	Vitamins	↓	Butter	firmer	Land use	↑
Fat%		SFA	↑	Cheese	↑	Biodiversity	↓
Protein%	↑	PUFA	↓	Milk powder		GHG	↓
		Flavour		Yoghurt	Viscous		

OMEGA 3 MILK

Elevated linolenic acid

- Linseed supplement

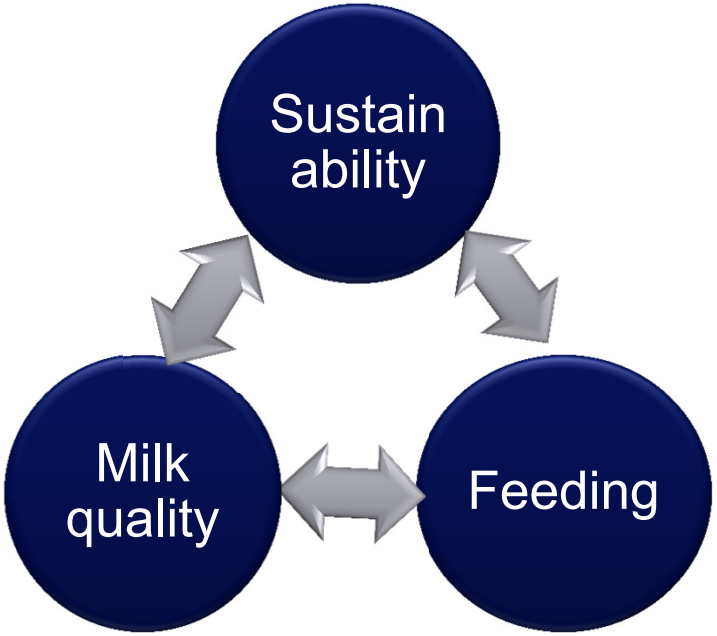
Production		Milk composition		Dairy products		Sustainability	
Yield		Vitamins	↓	Butter	soft	Land use	
Fat%		SFA **transFA**	↓ ↑	Cheese		Biodiversity	
Protein%		PUFA	↑	Milk powder		GHG	
		Flavour	oxid?	Yoghurt			

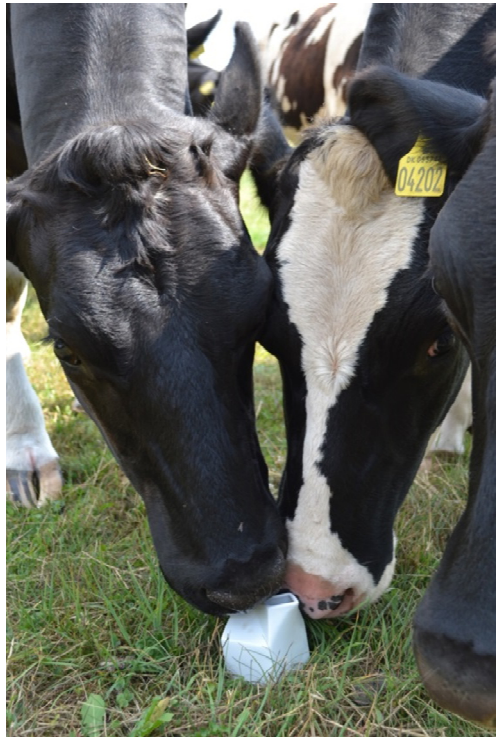
LOW CARBON FOOT PRINT MILK

High fat supplement, maize and grass clover silage, high concentrate

Production		**Milk composition**		**Dairy products**		**Sustainability**	
Yield	↑	Vitamins		Butter		Land use	↑
Fat%		SFA		Cheese		Biodiversity	↓
Protein%		PUFA		Milk powder		GHG	↓
		Flavour		Yoghurt			

FUTURE SUPER MILK





THANK YOU FOR LISTENING