Modelling methane emission from dairy cows

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Introduction

Methane production from dairy cows ~ 350 g per cow daily

Yearly production from cows in DK ~ 70 000 tons

Methane is produced by fermentation in the GI tract, notably the rumen (90-95%)

Methane energy loss ~ 6% of GE

This proportion is affected by level and composition of feed

During the last 10-15 years, the level and composition of cows' winter feed have changed

Leading question:

What is the possible effect on methane production of these changes in feeding ?

Purpose of this presentation:

To address the leading question by model simulation of methane production from lactating cows

Method (the model Karoline)

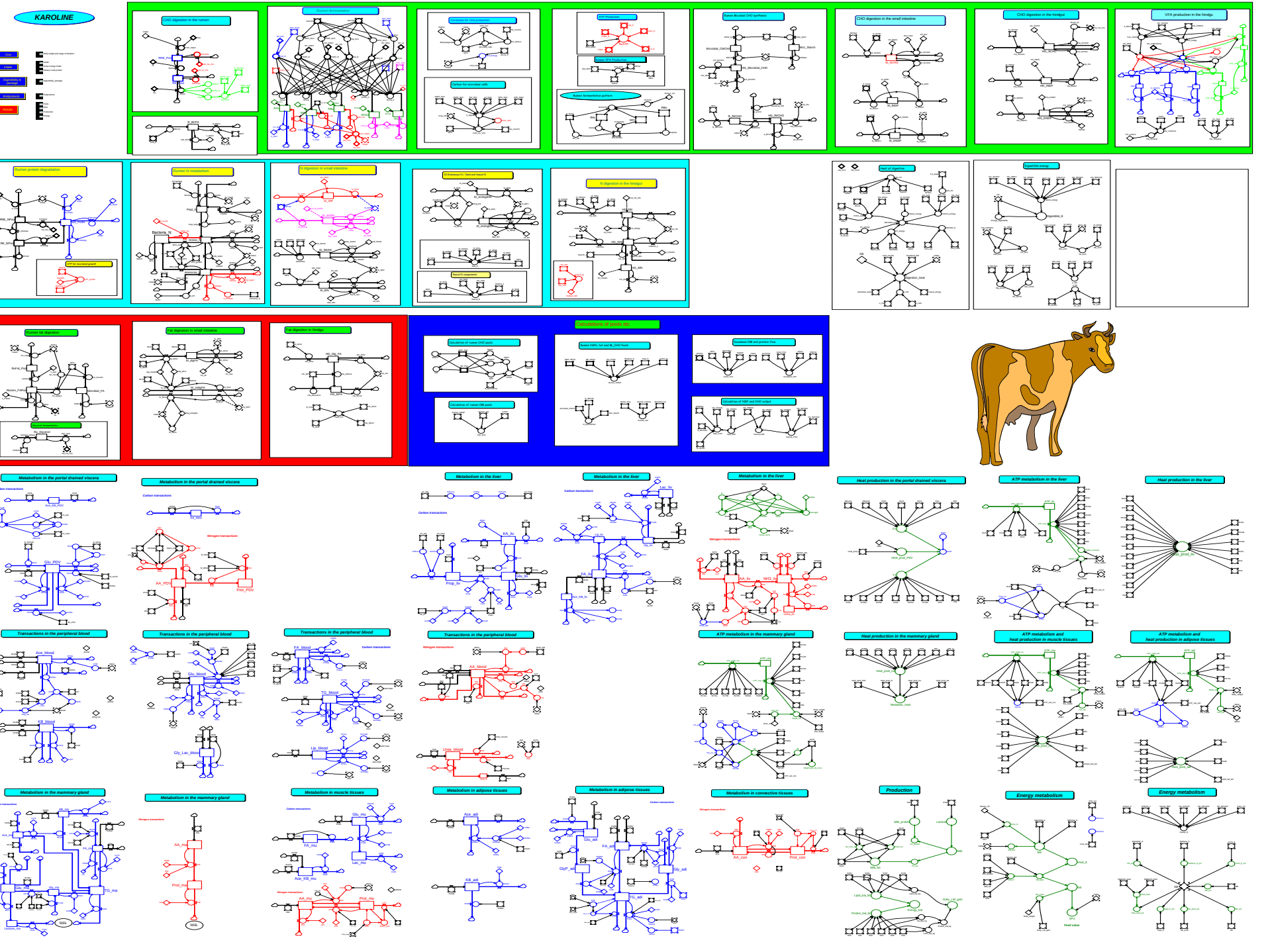
Karoline is dynamic, mechanistic simulation model of a dairy cow

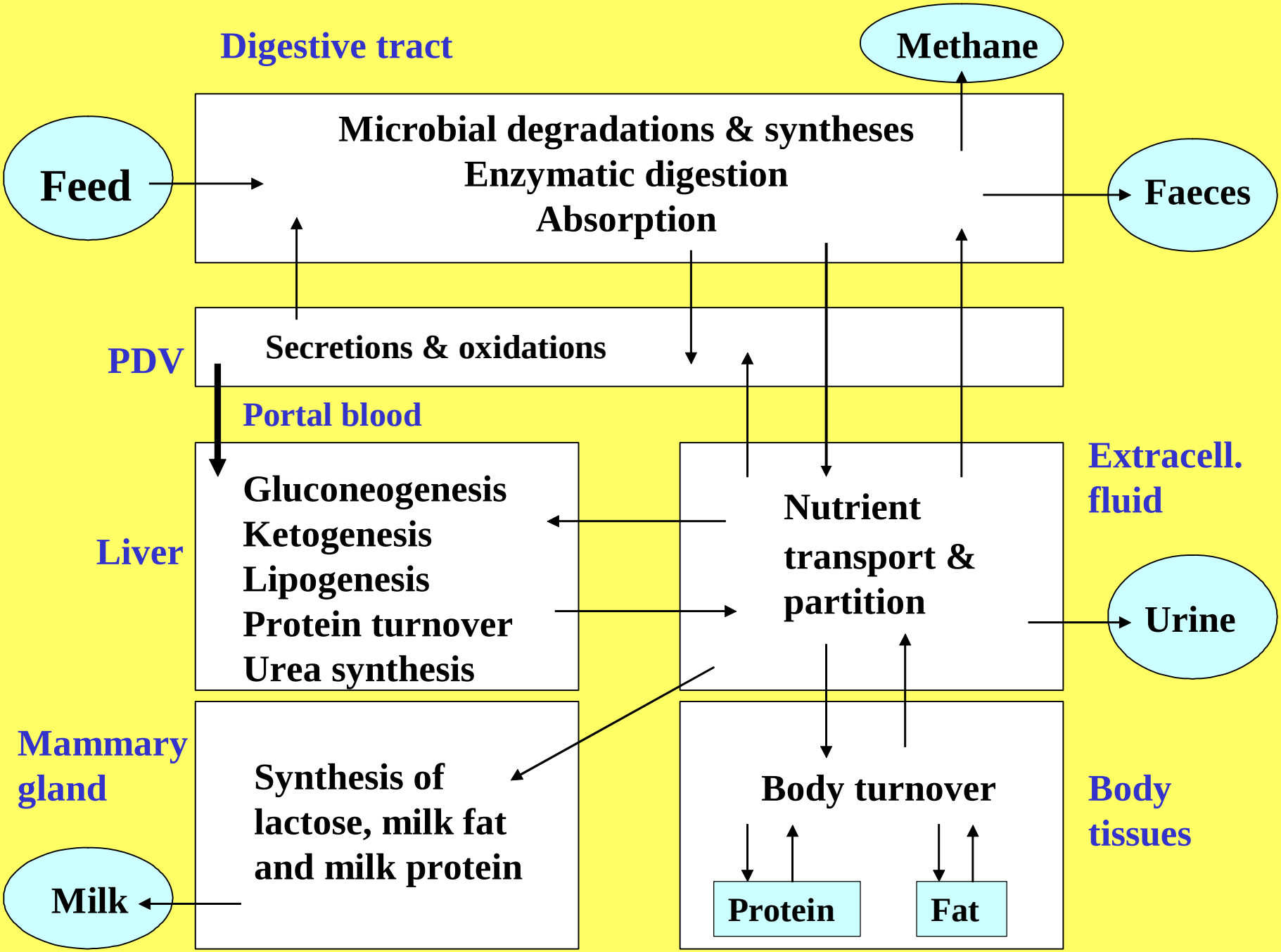
Karoline is developed in a Nordic co-work

The model describes rates of nutrient digestion, absorption and utilisation

From these rates, cow performance is predicted: milk production and composition, body weight gain and composition

Excretions of nutrient losses including methane are also predicted


KAROLINE
CHO digestion in the rumen
Rumen fermentation
Microbial CHO synthesis
CHO digestion in the small intestine
CHO digestion in the hindgut
VFA production in the hindgu
Rumen protein degradation
Rumen N metabolism
N digestion in small intestine
N digestion in the hindgut
Heat of digestion
Heat/Ath energy
Rumen fat digestion
Fat digestion in small intestin
Fat digestion in hindgut
Calculations of inputs etc
Calculation of rumen CHO pools
Rumen NAN, fat and M_CHO Pools
Calculation of NDF and CHO output
Metabolism in the portal drained viscera
Metabolism in the liver
Heat production in the portal drained viscera
ATP metabolism in the liver
Heat production in the liver
Transactions in the peripheral blood
ATP metabolism in the mammary gland
Heat production in the mammary gland
ATP metabolism and heat production in muscle tissues
ATP metabolism and heat production in adipose tissues
Metabolism in the mammary gland
Metabolism in muscle tissues
Metabolism in adipose tissues
Metabolism in connective tissues
Production
Energy metabolism


Digestive tract
Methane
Feed
Microbial degradations & syntheses
Enzymatic digestion
Absorption
Faeces
PDV
Secretions & oxidations
Portal blood
Liver
Gluconeogenesis
Ketogenesis
Lipogenesis
Protein turnover
Urea synthesis
Extracell. fluid
Nutrient transport & partition
Urine
Mammary gland
Synthesis of lactose, milk fat and milk protein
Body turnover
Body tissues
Protein
Fat
Milk

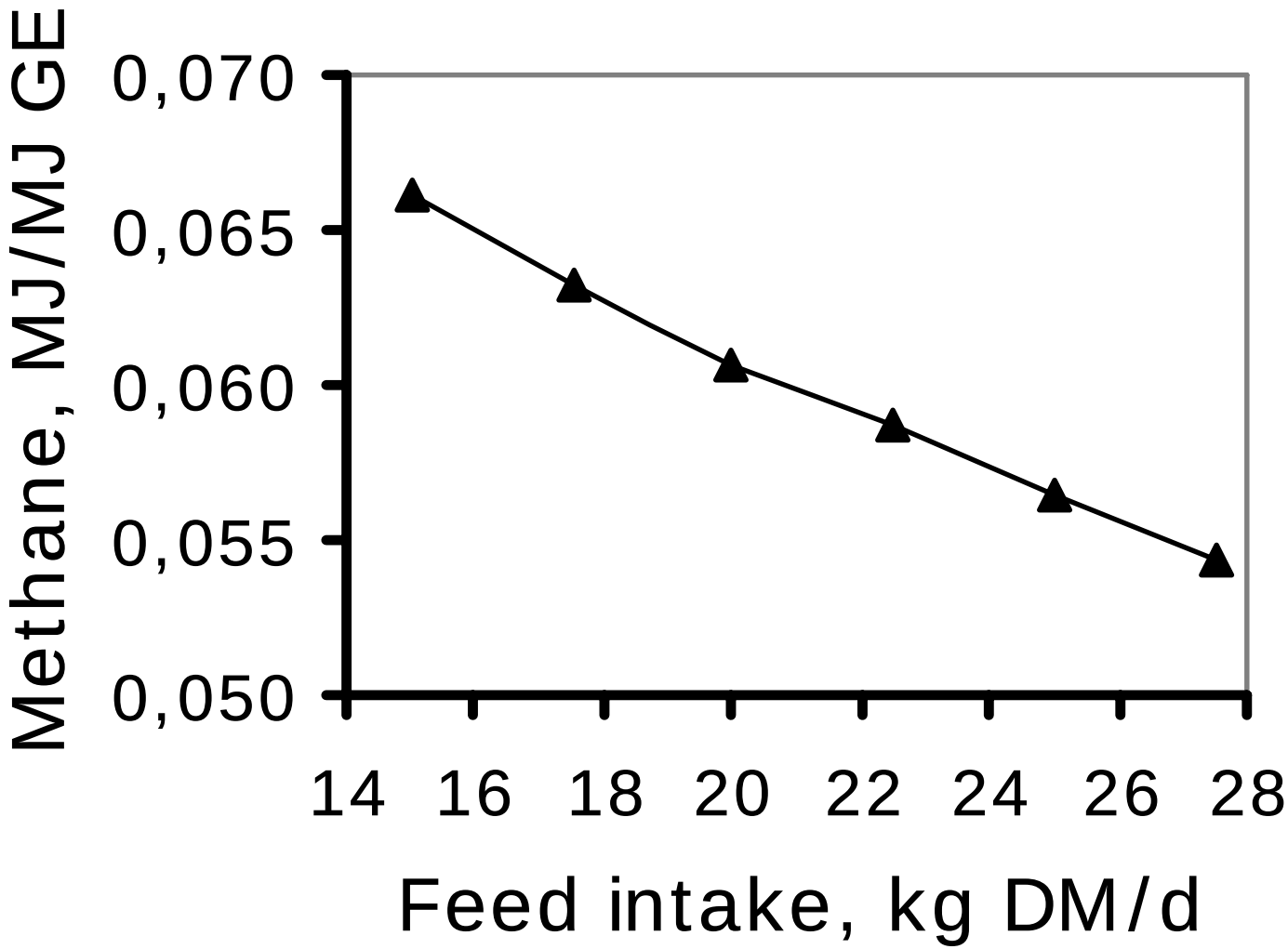
Test of the model

Karoline has been tested for its ability to give realistic predictions of methane production

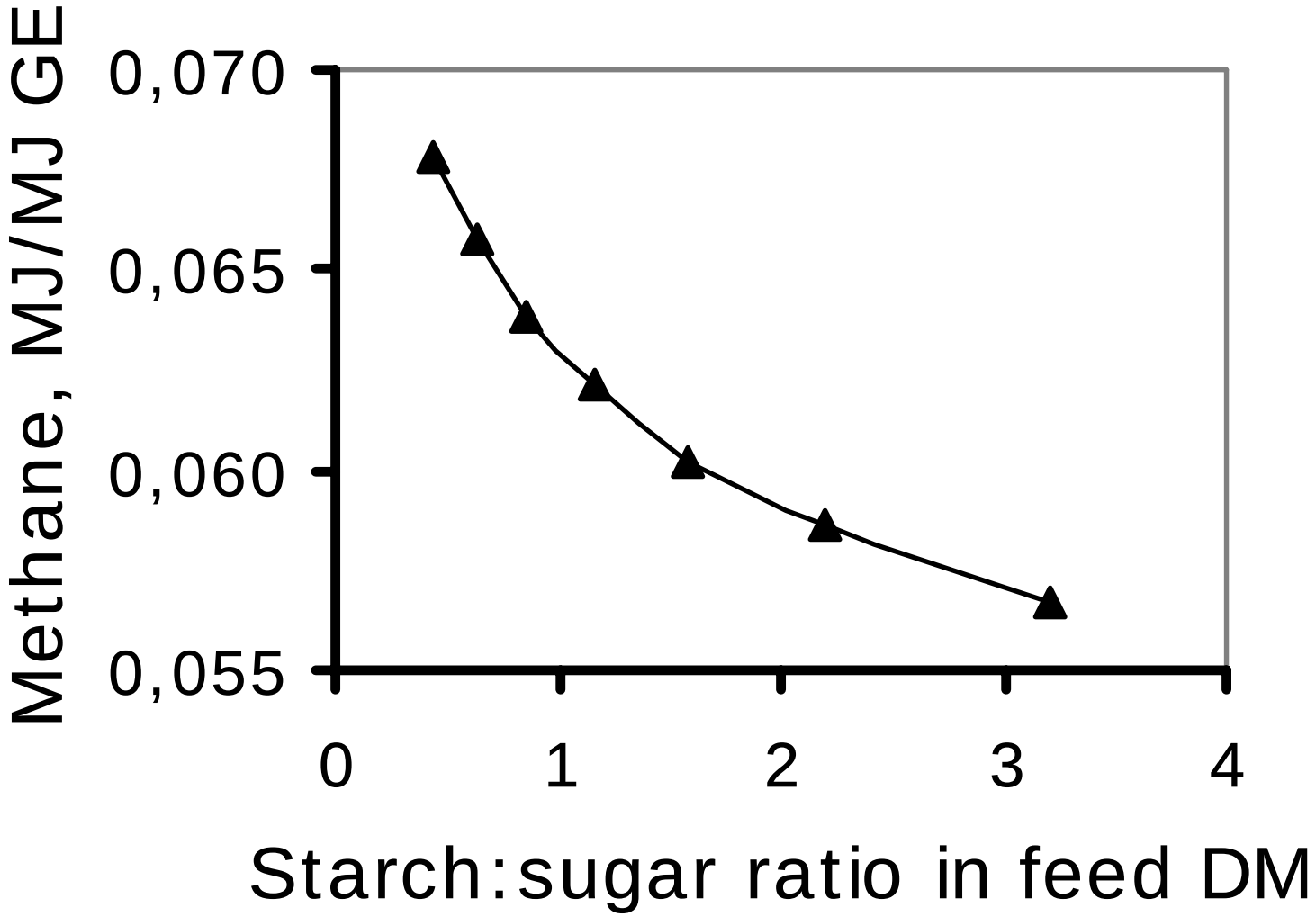
Simulations of 13 different types of diet have been compared with experimental data

In all cases, simulations showed the same trends as observed in real life

A few examples will be shown



Simulated effect of feed intake on methane production



Simulated effect of starch:sugar ratio on methane production. Starch + sugar: 43% of feed DM

Results

Changes in composition of winter-feed 1991-2002:
fodder beets + beet pulp decreased from 38 to 16%,
maize silage increased from 0 to 22% of DM

Consequences on chemical composition of feed:
lower sugar content, higher starch content,
i.e. higher starch:sugar ratio

During the same period, feeding level increased
from 18.2 to 19.5 kg DM/d

Chemical composition (g/kg DM) of the winter feed for dairy cows in 1991 and 2002

Chemical fraction [1)]	Winter 1991	Winter 2002
Crude protein	166	167
Crude fat	43	48
Sugar	200	85
Starch	76	151
Cell wall carbohydrates	426	467

[1)] Calculated by Weisbjerg et al. (2005) based on reports from The Danish Cattle Organization.

Methane production in dairy cows during winter periods 1991 and 2002 predicted with the Karoline model

Year	1991	2002
Feed intake, kg DM per cow daily	18.20	19.49
(A) Methane, g per cow daily	387	377
(B) Methane energy, % of GE	6.7	6.0
Decrease in (B) 1991-2002, %		10.4

Conclusions

Methane energy loss (% of GE) from dairy cows in DK has decreased in the winter-feeding period by 10% from 1991 to 2002 as a result of changes in feed level and composition

This corresponds to a 5-6% decrease on a yearly basis

The model Karoline is a useful tool for prediction of nutrient digestion, utilisation and excretion in lactating cows

Thank you

for staying alive