Effects of dietary forage proportion on maintenance energy requirement and energetic efficiency of lactating dairy cows

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Introduction

- There is evidence indicating that dietary forage proportion can influence maintenance energy requirement of dairy cows
  - An early study (Yan et al., 1997) reported a positive relationship between ME requirement for maintenance and dietary silage proportion

- However, this effect has not been considered in the majority of energy feeding systems for dairy cows used across the world
  - Normally, a single value for maintenance energy requirement ($MJ/kg^{0.75}$) is recommended for rationing dairy cows, irrespective of diet forage proportion

- There is a need to address this issue, especially for dairy cows managed under the low input and organic dairy production systems

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Objective

- The objective was to use a large calorimeter dataset of lactating dairy cows to evaluate the effects of dietary forage proportion on:
  - Metabolisable energy requirement for maintenance (ME_m)
  - Efficiency of utilisation of ME for lactation (k_l)

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AFBI calorimetric data

- 924 lactating cow data used in the present study – obtained from 32 calorimeter chamber experiments undertaken at AFBI from 1992 to 2010
  - 814 from Holstein-Friesian cows
  - 48 from Norwegian cows
  - 62 from HF crossbred cows
- Animal characteristics
  - Parity: 1st = 258 cows, 2nd = 206 and 3rd or over = 460
  - Days in milk: 20 to 354
  - Genetic merit (HF): low to high yielding cows
- Diet information
  - Forage only diets = 65, and mixed diets = 859
  - With mixed diets, forage proportion = 10 to 87% (DM basis)
  - Majority of diets based on grass silage

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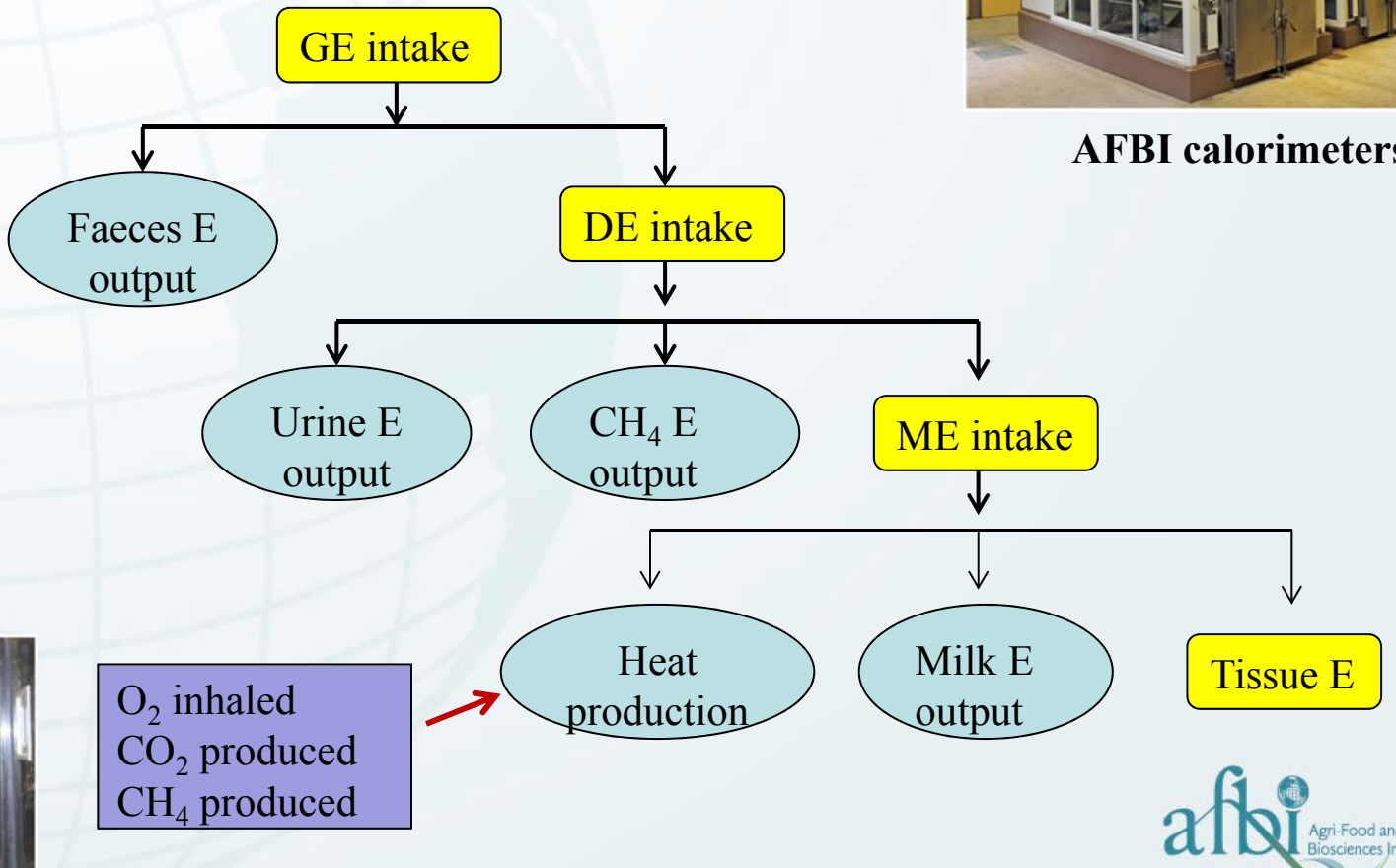
Calorimeter measurement

- Chamber measurement of energy intake and output

AFBI calorimeters



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Statistical analysis

- The whole dataset was divided into 3 groups based on forage proportion in diets (FP): FP < 30%, FP = 30% to 99% and FP = 100%

- Two statistical methods used to evaluate if there was any significant differences between the 3 groups of data in ME requirement for maintenance (ME_m) and efficiency of ME use for lactation (k_l)
  - ANOVA – Analysis of variance
  - Linear regression between ME_m or k_l and ME intake

- Effects of a number of factors were removed, including experiments, days of milk, parity, milk yield and genetic merit

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Calculation of ME_m and k_l

- ME requirement for maintenance (ME_m) and efficiency of ME use for lactation (k_l) for individual cows calculated using energy intake and output data

- ME_m ($MJ/kg^{0.75}$) = heat production minus energy losses from the inefficiencies of ME use for lactation, tissue change and pregnancy (AFRC, 1993)

- k_l = milk energy output (E_l) adjusted to zero tissue energy retention (E_g) divided by difference between ME intake and ME_m
  - $k_l = (E_l + a*E_g)/(\text{ME intake} - ME_m)$

Animal and diet data

	Mean	SD	Minimum	Maximum
Body weight (kg)	553	66.7	379	757
Body condition score	2.5	0.39	1.5	4.5
Days in milk	164	85.9	18	354
Lactation number	2.5	1.6	1	9
Milk yield (kg/d)	22.4	7.83	1.0	49.1
Forage proportion (%)	53	20.5	10	100

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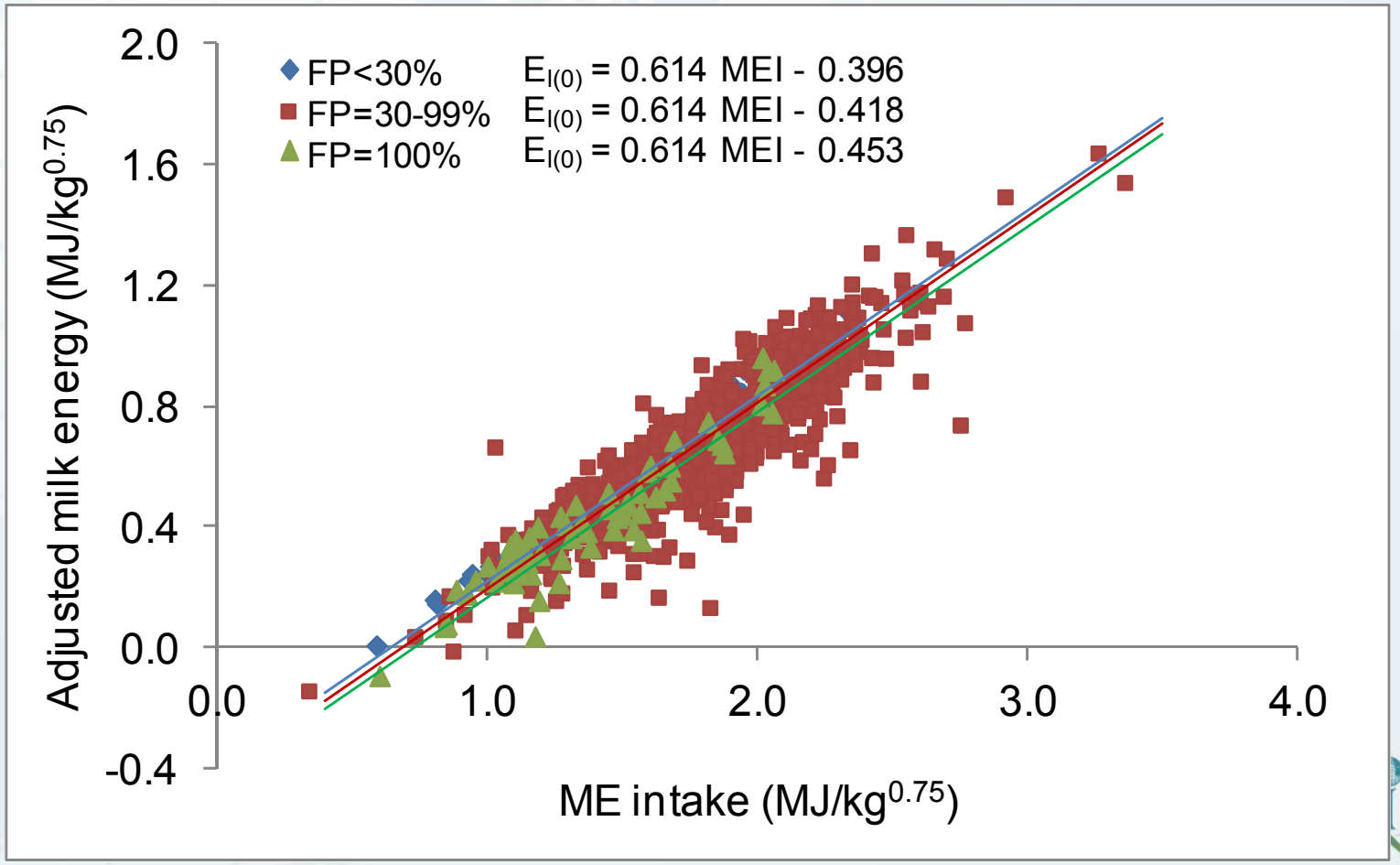
Energy intake and output data

	Mean	SD	Minimum	Maximum
GE intake	311	63.3	114	485
Faecal energy	79	21.1	25	150
Urine energy	11	4.1	2	59
Methane energy	21	4.4	8	38
Heat production	125	20.3	67	184
Milk energy	70	23.2	3	141
Energy balance	4	22.8	-88	71

$E_{I(0)}$ against ME intake

- Linear relationships between adjusted milk energy output and ME intake for the 3 groups of datasets (FP < 30%, FP = 30%-99%, FP=100%)



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AVONA test for ME_m and k_l

- ANOVA test – effects of diet forage proportions on ME_m and k_l

	Diet forage proportion			s. e.	*P*-value
	< 30%	30% - 99%	100%		
ME_m ($MJ/kg^{0.75}$)	0.647	0.672	0.725	0.033	0.021
k_l	0.645	0.642	0.634	0.046	0.340

- Results indicated that
  - ME_m ($MJ/kg^{0.75}$) increased with increasing diet forage proportion
  - Diet forage proportion had no effects on k_l

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Linear regression for ME_m

- Linear regression to examine if there was any significant difference in constants (with a common coefficient) or slopes (with a common constant) in the regressions of energy intake against energy ME_m or k_l

Forage proportion		Coefficient	Constants	R^2	P value
< 30%			-0.396		
30% - 99%	$E_{l(0)}$ =	0.614 ME intake	-0.418	0.88	< 0.05
100%			-0.453		
< 30%			0.543		
30% - 99%	ME_m =	0.059 ME intake	0.567	0.68	< 0.05
100%			0.617		

- Results indicated that
  - Increasing forage proportions increased maintenance energy requirement
  - ME_m ($MJ/kg^{0.75}$) increased with increasing ME intake

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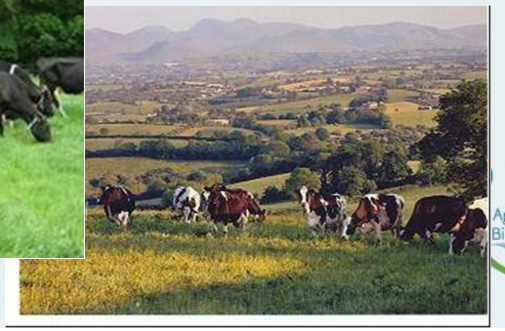
Conclusions

- Dietary forage proportion has no significant effect on the efficiency of ME use of lactation (k_l) for lactating dairy cows
- However, increasing dietary forage proportion can increase ME requirement for maintenance (ME_m)
- Dairy cows managed under the low input systems may require more energy than that currently adopted, to meet their basal metabolic rates



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Thank You