Modeling methane emission from dairy cows, barn, and storage

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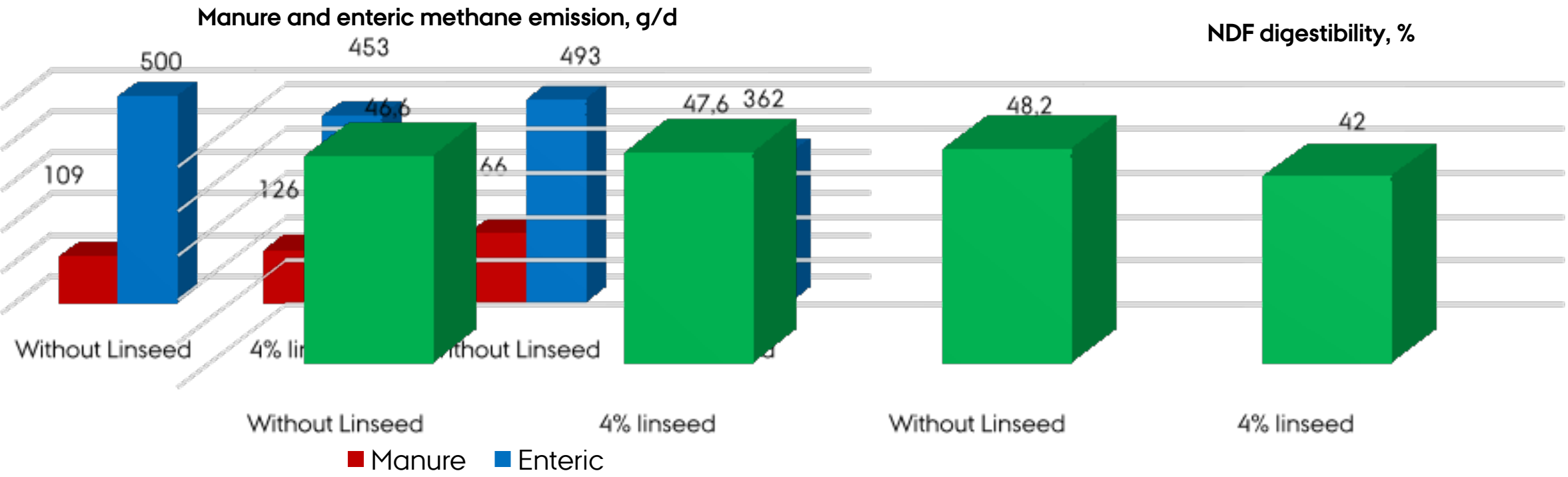
Introduction I

- ✓ Climate impact from agriculture and farm account in Denmark
- ✓ Contribution of ruminant livestock production:
  - Enteric
  - Barn emission due to manure/slurry management

Feed composition affects barn and storage emission (Hassanat and Benchaar, 2019)

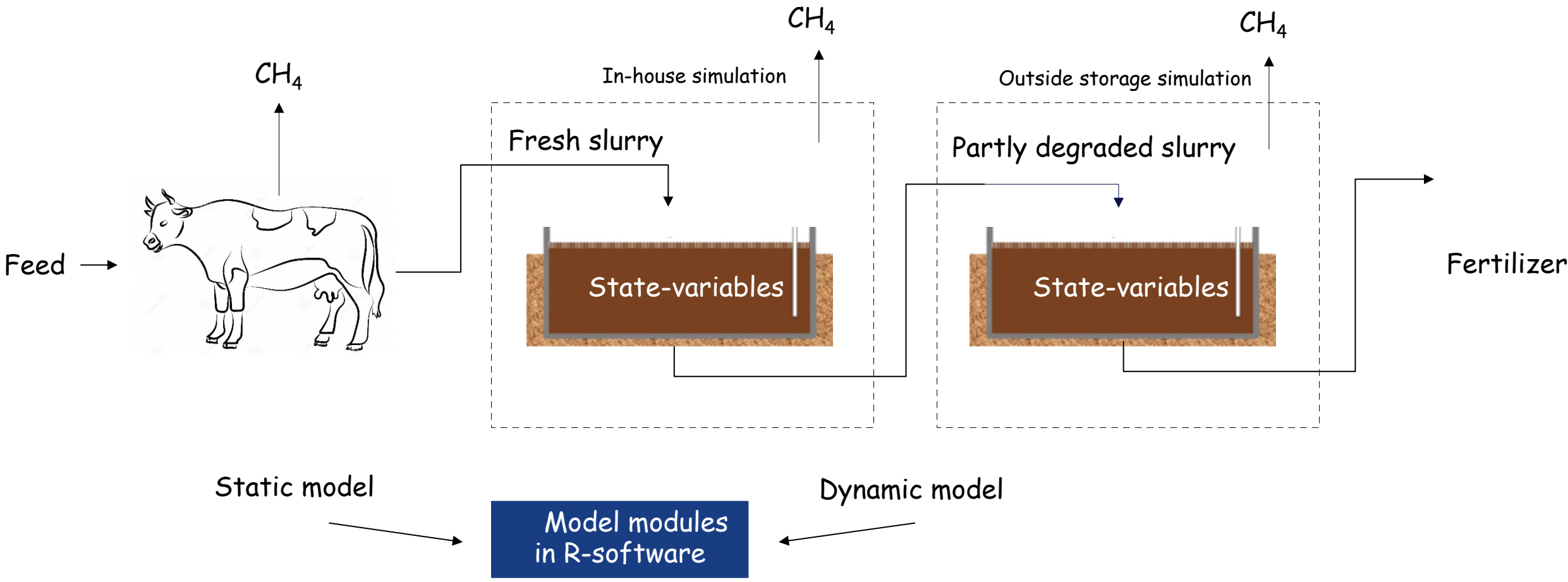


Objectives:

To develop a model to quantify enteric methane emission and emission from barn and storage based on diet composition, performance level and farm management to be used in farm account.

Materials and methods

Overall model description



State-variables = variable that change with the time such as crude fat, crude protein, volatile fatty acids, methanogen growth rate, methane emission.

Materials and methods

Define a farm, storage condition

General	
Animal class	cattle
Animal category	cow
Animals, section-1	200
Floor type	cubicle + slatted floor, ring channel
Removal technology	ring channel
Slurry under path	no

Technologies	
Acidification	none
Acid dose, kg m-3	0
Slurry cooling	none
Cooling effect, w m-2	20
Cooling time, days yr-1	365

Management	
Ventilation	natural
Pit depth, cm	120
Slurry removal frequency, days	28
Residual slurry depth, cm	40
Barn temperature, deg C	variable
Ventilation rate, m3 h-1 animal-1	600
Wash frequency, days	NA
Wash water, kg animal-1	0
Empty time of section, days	0
Grazing days, days yr-1	0
Grazing hours, h day-1	0
Grazing start, month	May
Excretion ratio, deeplitter/total	0
Pit/floor ratio	0.66
Area, m2 animal-1	8
Production area, m2 section-1	1600
Pit area, m2 section-1	1056

Three different diets

	Proportion, g/kg of diet		
Feedstuffs	49% Concentrate	70% Concentrate	91% Concentrate
Grass clover	255	128	0
Corn silage	243	121	0
Barely straw	13	50	88
dried beet pulp	120	160	201
Barley	222	232	239
Wheat, NaoH treated	0	77	155
Dried distillers' grain	0	69	138
Rapeseed meal	79	106	134
Soybean meal	54	27	0
Molasses	4	12	21
Palm fat	2	3	4
Vitamin mineral supplements	9	15	20

Calculation of feces composition

Feedstuffs (diets) composition

Extracting composition of individual feedstuffs from Norfor feed table:

- Organic matter, crude protein, crude fat, starch and sugar
- Residual fiber = organic matter - crude fat – crude protein – starch – sugar

Digested amount of different fractions in the diets

- Digested organic matter
- Digested crude fat
- Digested crude protein
- Digested residual fiber = digested organic matter - digested crude fat - digested crude protein – digested starch (= 100%) – digested sugar (= 100%)
- Undigested residual fiber = Residual fiber - digested residual fiber
- Degradable undigested residual fiber = Undigested residual fiber – indigestible NDF (iNDF)

Slurry volume calculation

- N in urine (g/d) = 12 + 0.3 × Nitrogen intake (g/d; NRC, 2021).
- Urine volume (kg/d) = 1.3 × dry matter intake (kg/d) + (1.1 × Na% in diet + 0.5 × K% in diet + 0.13 × N% in diet) – uncorrected milk × (0.1 + 0.03 × milk protein%; Bannink et al. 1999)
- Feces volume (kg/d) = -1.3 + 2.2 × dry matter intake (R2 =0.82; RMSE = 6.35; a data set from Animal and Veterinary Science Department)

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A mechanistic model of methane emission from animal slurry with a focus on microbial groups

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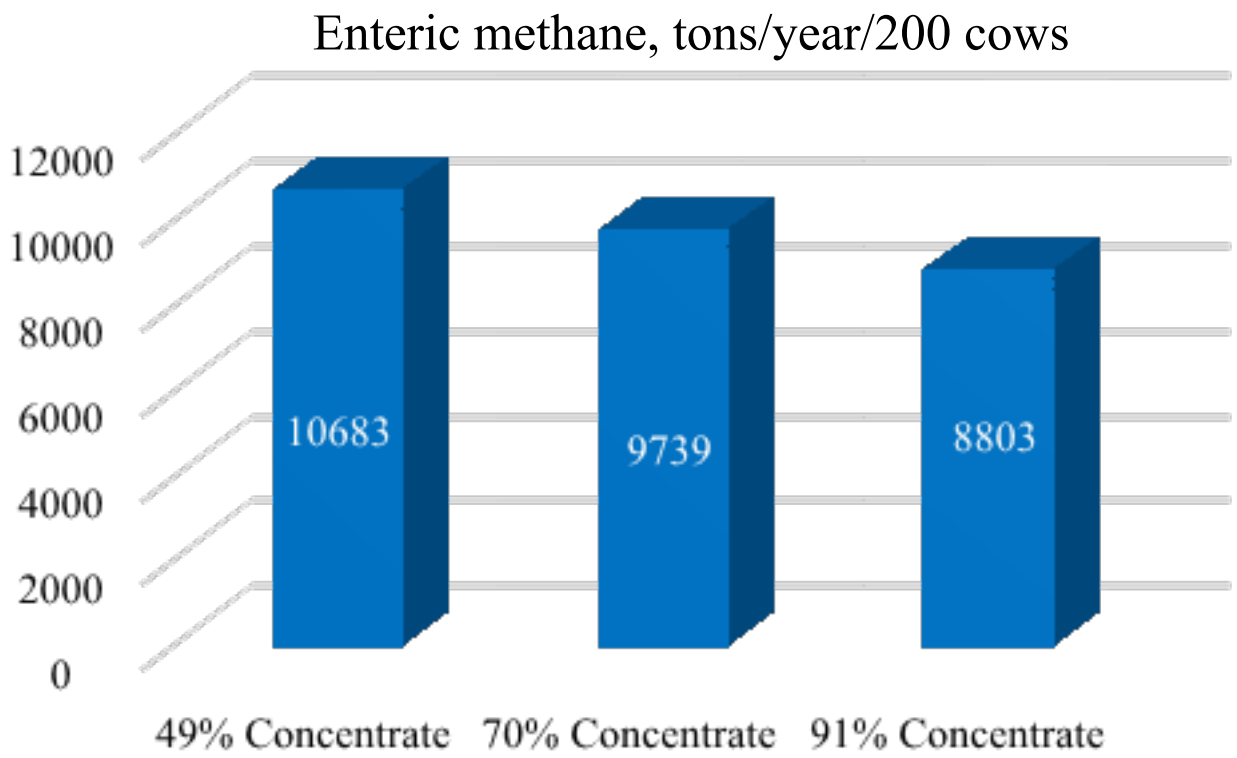
Results and discussion: Enteric methane

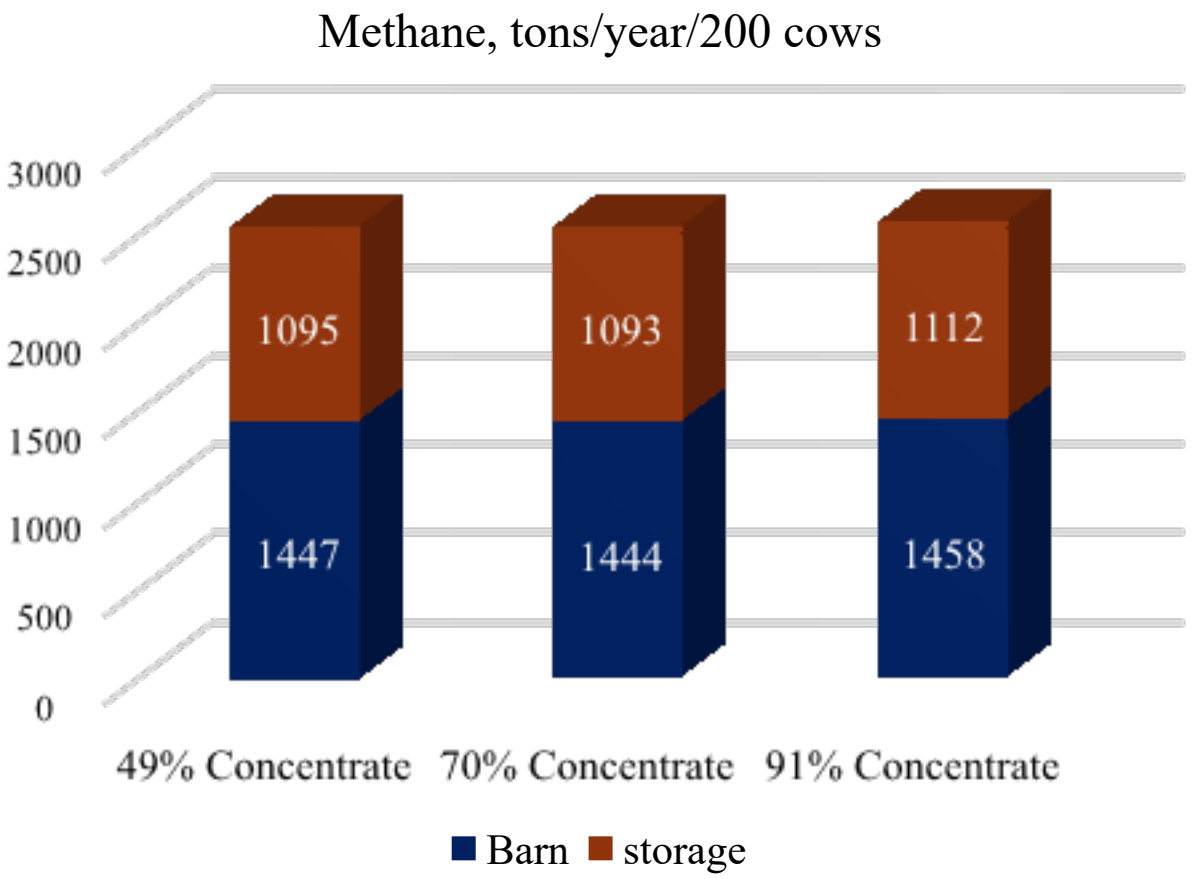


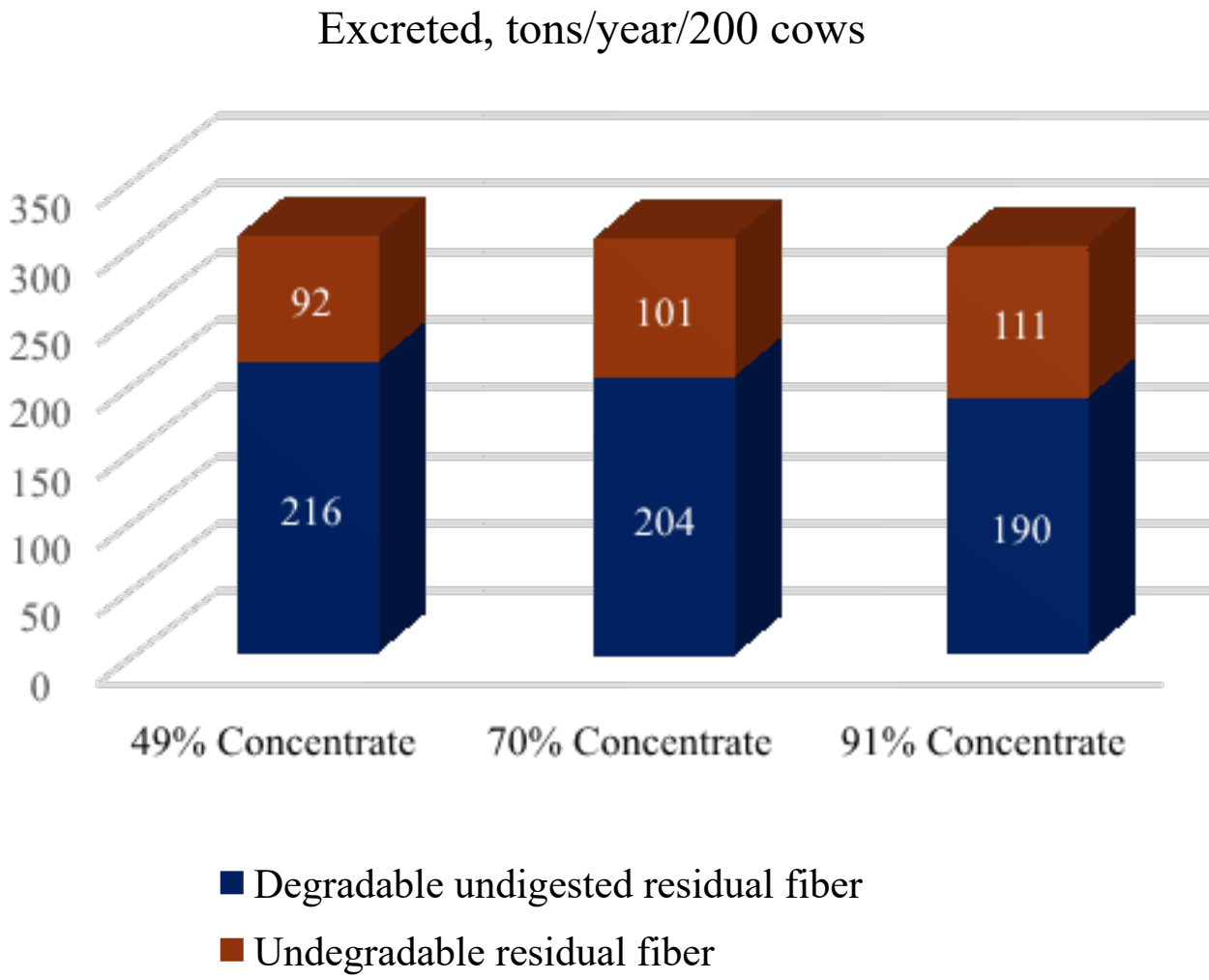
- Dry matter intake = 23.3 kg/day
- Enteric methane (g/d) = 76.0 + 13.5 × dry matter intake (kg/day) – 9.5 × ether extract (% of DM) + 2.2 × NDF (% of DM; Niu et al., 2017)

Diet composition, g/kg DM of diet

	Crude protein	Ether extract	Neutral detergent fiber (NDF)	Residual fiber	iNDF
49% Concentrate	27	34	311	459	54
70% Concentrate	26	37	297	445	60
91% Concentrate	26	39	283	432	66

Results and discussion: barn and storage





Conclusion

According to preliminary result of the present model the variation in feed composition:

- ✓ Has an impact on enteric methane.
- ✓ Does not have a considerable impact on the barn and storage methane emission.

Thanks for your attention

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Supplementary
Calculation of feces composition

- Feedstuffs composition
- Extracting composition of individual feedstuffs from Norfor feed table

Digested amount of different fraction

Digested organic matter (g/d) = organic matter intake (g/d) × 0.73

Digested crude fat (g/d) = 0.767 × crude fat intake (g/d) – 6.6 × dry matter intake (kg/d)

Digested N (g/d) = 0.962 × N intake (g/d) - 8 × dry matter intake (kg/d)

Digested residual fiber (g/d) = digested organic matter - digested crude fat - digested crude protein – digested starch (= 100%) – digested sugar (= 100%)

Residual fiber (g/d) = organic matter - crude fat – crude protein – starch – sugar

Undigested residual fiber (g/d) = total residual fiber - digested residual fiber

Degradable undigested residual fiber (g/d) = Undigested residual fiber – indigestible NDF (iNDF)