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Methane emission by growing pigs and adult sows as influenced by fermentation ☆

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Abstract

The fermentation of carbohydrates in pigs' digestive system, especially in the lower gut results predominantly in short chain fatty acids, gasses as CO_2, H_2 and CH_4. Methane (CH_4) is especially interesting as it contributes to the greenhouse gas emission and thus also to the global warming. CH_4 production and its relation to fermentation in growing pigs (74 diets) as well as adult sows (36 diets), were investigated in diets varying greatly in chemical composition. All diets were assayed in digestibility and energy balance experiments in respiration chambers. Growing pigs fed diets varying in total fibre content (2.8–40%) had a CH_4 production equivalent to 0.1 to 1.3% of digested energy (DE). Non-lactating sows fed at maintenance had a CH_4 production equivalent to 0.4 to 3.3 % of DE. Intensively fed lactating sows had the lowest CH_4 production (about 0.6% of DE). In general, the production of methane depended on fibre origin, however high variation was found between animals.

Keywords: Greenhouse gas; Digestibility; Total dietary fibre; Hydrogen; Digested energy

1. Introduction

Increased demand of high energy cereals for direct human use and increased availability of fibre rich ingredients, for instance in the feed milling or starch extraction/fermentation industries have increased utilisation of fibre rich by-products in pig feeds. Other benefits, such as increased well-being of animals, improvement of gut transit or reduction of stomach ulcers also favour an increased utilisation of fibre rich ingredients. An increased dietary fibre level is on the other hand associated with a reduced content of available energy (Jørgensen et al., 1996b). If the diet is not combined with high energy ingredients such as animal fat or vegetable oil the amount of feed required per produced animal unit is increased (Jørgensen et al., 1996a).

The fermentation of carbohydrates in the pigs' digestive system, specially in the lower gut, results predominantly in short chain fatty acids as acetic-, propionic- and butyric acid, gasses as carbon dioxide (CO_2), hydrogen (H_2) and methane (CH_4), urea and heat (Bach Knudsen and Jørgensen, 2001). From an energy and environmental point of view, CH_4 and H_2 are important as they correspond to combustible gases and represent a loss of energy, and CH_4 is especially interesting as it contributes to the greenhouse gas emission (Mikkelsen et al., 2005). The CH_4 productions by pigs vary with their age or live weight and

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the type of diet they receive (Noblet and Shi, 1993), however, information on gas production by pigs is rather limited. The aim of the present study was to quantify the methane emission from growing pigs and adult sows.

2. Material and methods

The data is based on experiments with growing pigs and adult sows carried out at the Research Centre Foulum from 1990 and onwards. The methane and hydrogen production as well as the consumption of oxygen and production of carbon dioxide were measured in respiration chambers as described in details by Jørgensen et al. (1996b). Heat production can be calculated on basis of the consumed amount of oxygen and the produced amount of carbon dioxide and methane (Christensen and Thorbek, 1987).

A total of 74 different diets were assayed with growing pigs in the weight range from 28 to 94 kg. The variation in the chemical composition is shown in Table 1. The experiments with adult sows comprised both non-lactating sows as well as lactating sows. A total of 36 diets varying greatly in chemical composition were tested (Table 2). The following treatments were tested: low and high fibre from sources as sugar beet pulp, wheat bran, potato fibre, pectin residue, pea hull, soya fibre and grass silage; high and low protein as well as low and high fat. Furthermore, experiments with growing pigs either fed a diet with Tagatose (a sugar that is predominantly fermented in the hind gut) or infused with short chain fatty acids in the caecum were performed. In addition, experiments with normal and finely ground, meal or pelleted diets and different breeds of pigs were included in the data set. In some experiments the diet was not analysed for dietary fibre (DF, non-starch polysaccharides (NSP)+lignin), therefore, DF was calculated as the residual fraction after substitution of the analysed content of sugars, starch, crude protein, crude fat and ash from the dry matter content. Total fermented DF (fDF) was in most cases

Table 1
Chemical compositions of diets ($N=74$) used for growing pigs (g/kg DM) together with energy intake, H_2 and CH_4 excretion

	Mean value	Range of values	Coefficient of variation
Chemical composition			
Crude protein	184	147–238	10.2
Crude fat	70	31–207	53.1
Starch	454	302–706	21.7
Total sugars	50	16–220	83.7
NSP	147	5–318	65.3
Soluble NSP	36	4–114	86.9
Total fibre[1]	184	28–400	45.5
DM intake, kg/d	1.72	0.87–2.39	18.8
ME intake, MJ/d	26.51	14.11–35.93	18.6
Total fibre intake, g/d	321	56–819	52.7
H_2, L/d	1.1	0–13.5	149.3
CH_4, L/d	3.4	0.3–12.1	64.6
CH_4-energy, % DE	0.49	0.03–1.29	58.9
Energy digestibility, %	84.1	60.2–97.7	8.9
Total fibre fermented, %	56.8	32.1–86.0	22.4
Live weight, kg	65	28–94	23.3

[1]The content of total fibre was calculated as the residual fraction after subtraction of the analysed content of sugars, starch, crude protein, crude fat and ash from the dry matter content.

Table 2
Chemical compositions of diets ($N=36$) used for sows (g/kg DM) together with energy intake, H_2 and CH_4 excretion

	Mean value	Range of values	Coefficient of variation
Chemical composition			
Crude protein	151	98–194	16.2
Crude fat	61	29–113	38.0
Starch	382	154–546	28.5
Total sugars	47	17–78	49.9
NSP	267	128–438	39.8
Soluble NSP	62	22–170	58.4
Total fibre[1]	320	151–536	38.6
DM intake, kg/d	2.20	1.48–4.87	36.4
ME intake, MJ/d	30.16	16.95–75.84	43.8
Total fibre intake, g/d	672	290–1377	39.5
H_2, L/d	0.8	0–3.2	88.0
CH_4, L/d	9.8	3.2–28.7	57.5
CH_4-energy, % DE	1.31	0.40–3.25	61.4
Energy digestibility, %	78.0	46.1–85.2	10.5
Total fibre fermented, %	62.1	26.2–87.1	21.2
Live weight, kg	225	192–298	12.2

[1]The content of total fibre was calculated as the residual fraction after subtraction of the analysed content of sugars, starch, crude protein, crude fat and ash from the dry matter content.

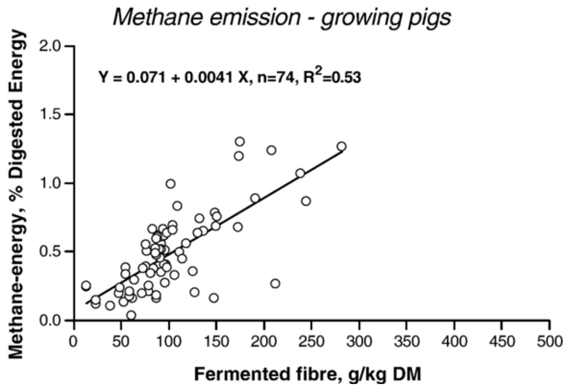

Fig. 1. Production of methane relative to digested energy (DE) in relation to amount of fermented DF in growing pigs.