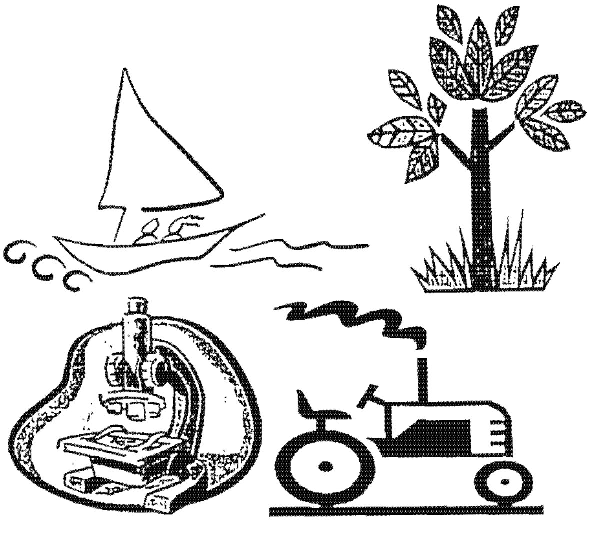
AGRICULTURAL AND BIOCHEMICAL DEVELOPMENT STRATEGIES IN THE 21th CENTURY

Proceeding of Fourth Symposium on Agricultural Sciences and Biochemical Engineering 2000

AGRI-BIOCHE 2000



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Edited by

Kasdi Subagyono
Abdul Hadi
I Wayan Nurjaya
M. Arif Yudiarto
Mulyono Baskoro

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Towards the 'environmental-friendly' animal agriculture systems

Agung Purnomoadi*, Mitsunori Kurihara, Takehiro Nishida, Fuminori Terada

National Institute of Animal Industry, Tsukuba kenkyudanchi POBox 5,
Ibaraki 305-0901, Japan
**Faculty of Animal Husbandry, Diponegoro University,*
Semarang, Indonesia

Abstract

The studies to reduce methane emission from livestock showed that a good feeding management is the absolute requirement. Diet containing high ratio of concentrate to hay produced methane lower than the diet containing low ratio of concentrate to hay. Feed with high protein produced methane gas lower than of low protein. Feeding manipulation by giving supplementation to condition rumen environment was also reported as potential methods to reduce methane production. Zinc sulfate supplementation or calcium fatty acids (CaFA) was reported successfully reduce the methane production, although the giving of zinc sulfate reduce feed digestibility, but no negative effect was observed on CaFA supplementation. Since high producing livestock required high dry matter intake (DMI), and it is linearly correlated with methane production, therefore the evaluation of cost for methane production from livestock must be calculated based on the unit of animal products. With this evaluation, high production livestock produce lower methane per unit products compared to that low production livestock.

Menuju sistem peternakan yang sayang lingkungan

Agung Purnomoadi*, Mitsunori Kurihara, Takehiro Nishida, Fuminori Terada

National Institute of Animal Industry, Tsukuba kenkyudanchi POBox 5,
Ibaraki 305-0901, Jepang
**Fakultas Peternakan, Universitas Diponegoro, ,*
Semarang, Indonesia

Penelitian guna menekan emisi gas methan dari peternakan menunjukan bahwa tatalaksana pemberian pakan yang baik adalah syarat mutlak untuk berhasil. Pakan dengan rasio konsentrat-hijauan yang tinggi terbukti memberikan gas methan yang lebih rendah dibanding pakan dengan rasio konsentrat-hijauan yang rendah. Kadar protein yang tinggi dalam pakan juga memberikan gas methan yang lebih rendah dibanding pakan dengan kadar protein rendah. Pemberian pakan tambahan berupa Zinc sulfate dan Calcium fatty acids (CaFA) dalam usaha mengkondisikan lingkungan dalam rumen memberikan hasil yang positif dalam menurunkan pancaran gas methan dari ternak. Ternak dengan produksi tinggi, mengkonsumsi pakan dalam jumlah yang lebih besar dibanding ternak produksi rendah. Konsumsi pakan berhubungan secara linier dengan produksi gas methan. Oleh karena itu, cara evaluasi efisiensi penggunaan pakan terhadap hasil gas methan harus mempertimbangkan output produk. Dengan cara ini, jelas terbukti bahwa ternak dengan kemampuan produksi tinggi menghasilkan gas methan per unit produksi lebih rendah dibanding ternak dengan kemampuan produksi rendah.

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National Institute of Animal Industry, Tsukuba kenkyudanchi POBox 5,
Ibaraki 305-0901, Japan
**Faculty of Animal Husbandry, Diponegoro University,*
Semarang, Indonesia

Introduction

The 1945 Indonesian constitution obliged the government to develop and to improve the nation. Development of the nation started by creating the well-growing people required fulfillment of protein in their food. This is a start line of livestock production system that is aiming to meet the people protein requirement. Data from Ministry of Agriculture showed the fulfillment of protein from animal is still low, or may be very low compare to others Asian countries, being around 3 g protein from targeted 5 g protein per capita per day. Figure 1 shows position of Indonesia in the world countries in correlation between animal protein intake and GNP value as summarized by Han (1998).

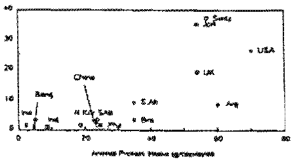

Figure 1. Relationship between animal protein intake (g per capita per day) and GNP (US$1000) selected countries.

Indonesia government has done a big effort to improve animal production mainly with two ways, by increasing animal numbers, and by introducing an applicable technology at farmer level. The increasing animal numbers is the instant way for lifting animal production, but the results showed that livestock productions are still left behind the national requirement. One of some possible reasons is the growth of animal production was imbalance with human population. The total human population of Indonesia was 195 million in 1995 and predicted increased to more than 200 million in 1999. The trend of livestock population were very slow increasing from about 15.0 million (1995) to 15.3 million (1999) for large ruminants (beef, dairy cattle, buffalo), and from 20.4 million (1995) to about 21.6 million (1999) for small ruminants (goats and sheep). An increase in numbers of ruminants would put huge pressures on many resources including forests and land that might be afforested and consequently will result in increase methane production and nitrogen excretion to the environment.

This paper is aiming to discuss the emission of methane from livestock and introduce the possibility methods on reducing that emission from feeding management to meet the ideal 'environment-friendly' animal agriculture in the future.

is also an attractive target since reduction of methane is usually associated with improved productivity. It is estimated that of the enteric source of methane, beef and drought animals contribute 50%, dairy cows 19% and only 9% from sheep (Crutzen et al., 1986). Methane emission of global cattle population of 1.3 billion are estimated to be 58 million tons/year, or 73% of the emissions from all livestock species (US EPA, 1994). At least 50% of the global cattle population is located in developing countries, many of which are in tropical regions characterized with poor quality forages.

Studies relating with depression methane emission from ruminants

Rumen is the main site of ruminant stomach that has a unique ability to convert low quality of plant materials into useful product. In adult ruminants the rumen capacity represent 85 % of the total stomach. Microorganism (bacteria, fungi and protozoa) in the rumen plays an important role to digest that plant materials which cannot be digested by the host enzymes. The materials are fermented into volatile fatty acids, carbon dioxide, and methane by microorganisms.

The efforts to depress methane emission in ruminants have been done for a long time ago with an aiming at maximizing the energy utilization in animal. The loss of energy from feed to methane is accounted for 5.5 - 6.5% of gross energy (GE) intake (Johnson and Ward, 1996), but the values of 2 - 12% (Czerkawski, 1969) have been reported on some diets. Formation of methane by methanogenic bacteria in the rumen, however, has a positive function to microbial growth by eliminating hydrogen that is toxic for microorganism. Thus, the effort to reduce methane from digestion process in rumen must consider on providing a suitable environment for rumen microorganism.

Feeding manipulation possible to reduce methane production

Methane production from ruminants depends on the balance of nutrients absorbed which correspond with efficiency of fermentative digestion in rumen, and the efficiency of conversion of feed to animal product, in form of milk, meat or drought power (Leng, 1993). Production of methane in ruminants is correlated with dry matter intake (DMI) (Figure 3) (Kurihara et al., 1999; Shibata et al., 1993; Kriss, 1930), type of carbohydrate digested (Moe and Tyrell, 1979), chemical composition in diet, and digestibility (Holter and Young, 1992; Shibata et al., 1992) at various maintenance level. Among ruminants, the methane productions is proportionally linear with 'Livestock units' (cattle = 0.8, sheep or goats = 0.1) (Gibbs et al., 1989).

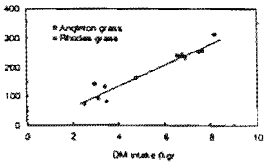

Figure 3. The relationship between the dry matter intake (DMI) and methane Productions for cattle fed on tropical forage diets, Angleton and Rhodes grass (adapted from Kurihara et al., 1999).

Studies on reducing methane production by feeding manipulation has been well investigated and documented by Kurihara et al., (1997). They clearly showed that in lactating cows, the diet containing high concentrate reduced both methane productions per DMI compared with the diet containing low concentrate. They also investigated the effect of crude protein (CP) in the diet on methane production by one series experiment

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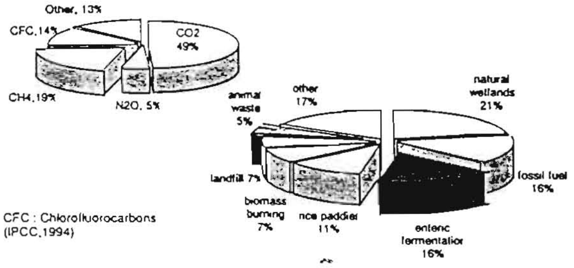

CFC : Chlorofluorocarbons
(IPCC,1994)

Figure 2. Composition of greenhouse gases and relative contribution of biological resources to global production of methane in the atmosphere.

Agriculture and greenhouse gases

The increasing world temperature in the recent decades, called greenhouse effect, is due to the changed of proportion of gases accumulated in the atmosphere (Figure 2). In this compositions and accumulation rates, it can be estimated that the world temperature will rise about 0.5 to 1 C in the next 25-50 years. Undoubtedly, contamination of the atmosphere with carbon dioxide, methane and the other greenhouse gases must be reduced or the future of the earth is threatened. From figure1, it is clearly accountable to the major industrial countries, which consume around 70% of world's oil production, contributed carbon dioxide for almost 50% of greenhouse gases in the atmosphere by their combustion of fossil fuel. The other greenhouse gases arise from a variety of activities; chlorofluorocarbons have been created by man, but will be phased out of production by legislation. Methane is an important component of greenhouse gases in the atmosphere, and is the most associated with animal agriculture. This gas, although contribute only 19% of the overall warming, is a major component in greenhouse gases because the global warming potential of methane is for about 21 times that of carbon dioxide. Therefore, to stabilize its concentration in the atmosphere, methane production needs to be decreased by mere 10-20% compared with 80-85 % reduction needed for other gas (Table 1).

Table 1. Approximate reduction in anthropogenic emissions requ
stabilize atmospheric concentration at current levels (E

Gas	reduction required	Gas	reduction required
Carbon dioxide	50 - 80 %	Chlorofluorocarbons	75 - 100 %
Methane	10 - 20 %	Carbon monoxide	Freeze
Nitrous oxide	80 - 85 %	Oxides of nitrogen	Freeze

Indonesia reported the composition of greenhouse gases for 1994 was being 82.8, 14.9, and 2.1% for CO_2, methane, and N_2O, respectively. The main source of CO_2 emission was from forestry and energy sector, to about 97% of total emissions. Total methane emission was contributed mainly (51%) by agricultural sector, which 70 and 30% of its came from rice field and from livestock, respectively (State Ministry for Environment, 1998).

Methane from Livestock

Animal agriculture contributes methane gas from two ways, i.e. direct and indirect contribution. The direct contribution is through the methane produced from fermentative digestion of carbohydrates contained in diets by microorganisms in the rumen, while the indirect contribution is from anaerobic decomposition of feces. Ruminants animal produce methane in a large portion (15-20%) of the 19% methane in total greenhouse gases (IPCC, 1994). Domestic ruminants represent one of the few sources than can be manipulated and it

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comparing four level of protein (4, 7, 9, 12%) in goats and two level of protein (6.5 and 8.5%) in dairy cows. The conclusion have been made that the daily methane production will be negatively correlated with daily CP intake if ruminants have fed sufficient CP above the maintenance energy level. Those studies, however, showed that high quality diet in sufficient feeding management is possible to reduce methane production.

Conditioning rumen environment

Methanogenic bacteria attach the surface of protozoa that produce a relatively large amount of hydrogen to form methane. Therefore, by eliminating the growth of protozoa in the rumen, commonly called the rumen defaunation, emission of methane may be reduced. Zinc sulfate demonstrated the ability to defaunate rumen at level greater than 1000 ppm supplementation on ruminant diets (Durand and Kawashima, 1980). In experiment on dry cows fed zinc sulfate supplementation (35 g/day) showed that methane production was decreased by 60% compared to that fed without supplementation (Kurihara et al., 1997). But, the result showed the negative effect of zinc sulfate supplementation by decreasing DM digestibility and DMI.

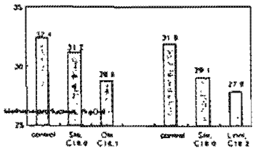

Figure 4. Effect of calcium fatty acid (CaFA) supplementation in diets fed on goats on methane production (adapted from Kurihara et al., 1997).

Calcium fatty acids (CaFA) was also added to diet and investigated for reducing methane emission. This study is based on that some microorganisms in the rumen use hydrogen to hydrogenate the double bonds of unsaturated fatty acids, therefore the addition of unsaturated fatty acids to the diet may result in an inhibition of methane production. Result from studies on goats showed that methane production was decrease by about 15% in animal fed on diets with linoleic acids (Figure 4), and the amount of decrease was became greater as the number of double bonds of fatty acids increased (Kurihara et al., 1997). Moreover, the degree of reduction was influenced by the nature of CaFA, feeding level and hay-concentrate ratio. Similar study on cattle showed that methane production per DMI in dry cows tend to decrease about 7-9% (17-23 l/d), but smaller in lactating cows by 4% (22 l/d) (Nishida et al., 1998). From these results, it is concluded that feeding of CaFA is effective in suppressing methane production without reduction of productivity.

Methane production per unit product

The strong relationship between methane production and dry matter intake is widely known. In general, cows producing high milk require more DMI than that of low milk producing cows, and consequently, high milk producing cows will release more methane to environment than low milk producing cows. Therefore, the value of methane production per unit animal production should be considered in evaluation of the cost of methane, as an index value for comparing greenhouse emissions of livestock under different feeding systems.

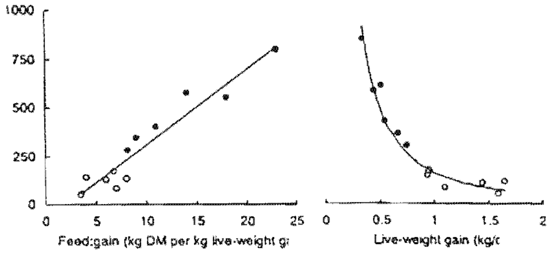

Figure 5. Relationship between methane production (g/kg live-weight gain) with feed-gain ratio and live-weight gain (kg/d).

Kurihara et al., (1997) reported that as daily 4% fat-corrected milk (FCM, kg/d) increased, daily methane production also increased. However, methane production per unit FCM hyperbolically decreased following the equation, $y = 8.19 + 300/FCM$ ($n = 115$; $r = 0.82$). With this equation, we calculate that if FCM increases from 5 to 10, 20, and 30 kg/d, methane production per unit FCM decreases from 68 to 38, 23, and 18 liter/kgFCM, respectively. The similar tendency was also found on beef cattle as shown in Figure 5 (Kurihara et al., 1999).

Overall Conclusions

The attempt to fulfill protein requirement for people is an everlasting effort. Instant way by increasing animal numbers may be only suitable in short term. In the long term, when consideration to control methane emission is also taken account to, this method should be accompanied with the effort to improve animal management, especially in feeding management. In the point of view from animal agriculture science, the problems for developing animal production in Indonesia are mainly related to the hot climate results in low quality of tropical forage, while animal required more feed intake than of in low temperature.

With those facts, therefore, we have to work harder if we truthfully want to bequeath a wonderful world to the next generation.

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