

REDUCTION OF METHANE PRODUCTION FROM BUFFALO HEIFERS FED SOY-SAUCE BY-PRODUCT IN SOUTHEAST ASIA

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ABSTRACT

Eight swamp buffalo heifers (age 1.5 year, weight 160 kg) were fed a basal diet consisted of Napier grass (*Pennisetum purpureum* sp) and commercial concentrate at a ratio of 70:30. Four of them received the basal diet only (BDO), while the other four were given soybean pulp at amount of 25% of total concentrate (BD-SP). The buffaloes were adapted to the diets for two months prior to data collection periods. Daily intake of dry matter (DMI), gross energy intake (GEI), methane production and live-weight gain were measured. Methane measurement utilized the facemask method equipped with a methane analyzer (Horiba Ltd., Japan), and was performed for 10 minutes at 3 hour intervals over two days. Results indicated that the methane conversion rate (MCR; CH₄ MJ/100 MJ GEI) of the BD-SP-fed buffalo was lower than that of the BDO group (12.0 vs. 10.5), as was the DMI (BD-SP: 4.55 vs. BDO: 4.76 kg/d), and the methane production per kgDMI (31.8 vs 28.7 g/kgDMI). The buffaloes receiving BD-SP had a higher daily gain than those receiving BDO (0.45 vs. 0.35 kg) therefore, the methane production/kg weight gain ratio of BD-SP buffalo was significantly lower (295 gCH₄/kg) than that of the BDO buffalo (443). We compared these values to those for cattle in temperate and tropical conditions and to values predicted by a general equation and a tropical-conditions equation. Our results suggest that supplementation by this common Southeast Asian food industry by-product can lead to a significant mitigation of methane in tropical climates.

Key words: swamp buffalo, Methane Conversion Rate, soybean pulp

INTRODUCTION

The greenhouse effect of methane has been considered high compared to another gases, thought to be around 20 times that of carbon dioxide. The methane production from enteric fermentation in animal agriculture contributes around 20% of the total global methane. Study on methane production from ruminants, such as beef cattle, dairy cattle, goats and lambs, has been pursued intensively. However, such study on water buffalo is still somewhat sparse. This has been caused by the high cost of equipment for measuring methane production in the location where buffalo are raised. Water buffaloes are ruminants living mainly in the tropics, and are considered potentially the most serious methane contributors due to their ability to utilize low quality tropical feedstuffs (Devendra, 1992).

The population of water buffaloes in the world is about 138 million, and almost ninety-seven percent of them are kept in the Asian region (FAO, 1986). There are two types of water buffaloes, i.e. riverine and swamp; thirty percent are swamp buffaloes that mainly found in Southeast Asia and Southern China. Swamp buffalo are characterized by their capacity to eat more than cattle, their ability to digest more fibrous feed. The swamp buffalo plays an important role in small holder farming systems by providing draft power for paddy fields. Most buffaloes are raised by small holder farmers who never think about production efficiency nor have ready means to supplement their animals' diets. In Indonesia, buffalo are mostly fed rice straw that is cut and carried to buffalo houses or field grass during shepherding

Mitigation of methane production in tropics is important because more than half of the livestock population is raised in this area. Moreover, the feed requirement in the tropics for similar production tends to be higher than that in the subtropics due to the low quality of feedstuffs. Feedstuffs in the tropics are characterized by high fiber, high lignin and low digestible fractions. Therefore, the animal needs more feed per unit of production, and emits higher methane levels because dry matter intake is highly correlated with methane production (Shibata *et al.*, 1993). Improving feed quality is one of the proven methods to reduce methane production (Leng, 1993). Of course, improving feed quality by supplementation with better quality feedstuffs will increase the production cost. Supplementation by cheaper feedstuffs such as by-products of the food industry should be explored for improving productivity and decreasing methane production. Soybean pulp (SP), the by-products from the soy-sauce industry, is one of the most promising feedstuffs for those functions due to the high protein content (more than 18%) and energy.

This study was aimed at investigating the methane conversion rate (MCR) of low-quality feeds given to buffalo in Southeast Asia, and

particularly, in Indonesia, and the effect of dietary supplementation by soybean pulp from the soy-sauce industry on animal performance and methane production.

Materials and Methods

Eight swamp buffalo heifers (aged 1.5 year, weighed 160 kg) were fed a basal diet consisting of Napier grass (*Pennisetum purpureum* sp) and commercial concentrate at a ratio 70:30. They were divided into two groups: one group received the basal diet only (BDO) while the other group was given soybean pulp for 25% of the total concentrate (BD-SP).

The grass was wilted for 7 days and then chopped to a 5-10 cm length prior to feeding. Soybean pulp was sun-dried and ground prior to being mixed with concentrate. The diet was set up to contain 12% crude protein and allowed to meet the requirement of DMI at 3% of weight. The concentrate was given twice a day, i.e. 0700 and 1500 h, while the grass was given at 0900 and 1700 h. The buffaloes were adapted to the feeding regime for two months prior to data collection.

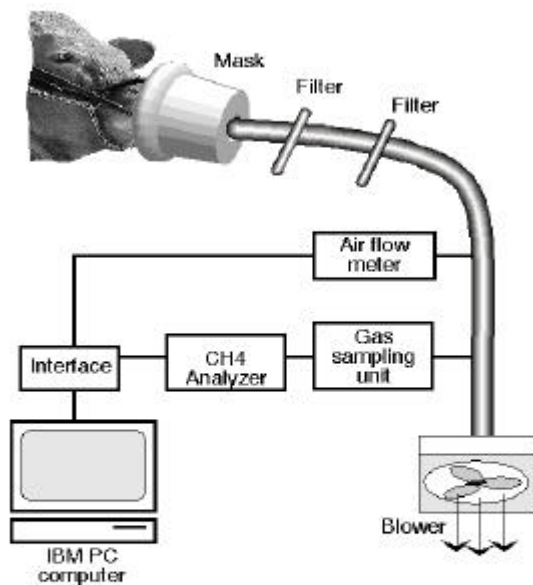


Figure 1. The structure of facemask method for methane production

Daily intake of dry matter (DMI), gross energy intake (GEI), methane production and daily live-weight gain were measured. DMI was measured by weighing the feed given and the residual. The GEI was determined by multiplying the DMI and energy content of the feed. Methane production was measured by facemask method equipped with following four components; (1) main airflow component, (2) air sampling component, (3) methane analysis component, and (4) data record and calculation

component. Main airflow component consisted of mask for collecting the breathe gas from mouth and nose of animal, pipe and valve to flow the gas and vacuum cleaner functioned as blower to inhale the gas. Gas from the mask was sent to air sampling component to remove the dust and moisture

in the sample gas prior to send to methane analyzer. Gas from mask was also sent to airflow-meter (STEC SEF-6470, Horiba Ltd, Japan) for measuring the volume of airflow. Methane analysis component was methane analyzer (VIA-510, Horiba Ltd., Japan) for determining the concentration of methane. These data of airflow and methane concentration was recorded continuously in connected IBM PC/AT compatible computer by TestPoint™ program (TestPoint™ Techniques & Reference, 1999). The structure of methane measurement using facemask method is presented in Figure1.

Gas collection was performed for 10 minutes at 3 hours intervals over two days (Kawashima, *et al.*, 2001). Daily live-weight gain was measured after the buffaloes were raised for 12 weeks..

Results and Discussions

The compositions of the two diets is presented in Table 1. Chemical analysis showed that soybean pulp contained high levels of protein (29.6%), fat (21.3%) and energy (4511 cal/g), and that these levels were higher than those of commercial concentrate. In fact, this composition suggests that soybean pulp has great potential as a feed, even to replace existing commercial concentrates. The limitation on usage will come from its higher salt content (23.1%), because too much salt can decrease feed intake (Agricultural Research Council, 1980; Church *et al.* (1974).

Table 1. Chemical composition of feedstuff given to animal in this study (DM basis)

Compositions	Napier grass	Commercial Concentrate	Soybean pulp
Organic Matter, %	90.9	81.1	69.4
Crude Protein, %	10.2	7.6	29.6
Ether Extract, %	1.0	2.6	21.3
Crude Fiber, %	33.4	16.7	14.0
Gross Energy, cal/g	3611	3321	4511
NaCl, %	nd	nd	23.1

nd: not determined

The daily live-weight gain, dry matter intake (DMI), DMI contributed by grass and concentrates, and its energy utilization in BDO- and BD-SP-fed buffalo heifers is presented in Table 2. The ratio of Napier grass and concentrate in feed consumed between BDO and BD-SP groups was similar ($P>0.05$), at 68:32 and 67:33, respectively. The tendency was for addition of soybean pulp (the by-products from soy-sauce industry) to decrease total dry matter intake (DMI), either from Napier grass (BD-SP: 3.05 kg vs. BDO: 3.22 kg/d) and from total concentrate including soybean pulp (BD-SP: 1.50 vs. BDO: 1.54 kg/d). The decrease in DMI was considered as an effect of the salt in soybean pulp, that was accounted around 2.1% in total feed intake.

This amount, even far below the 10% limit of salt content in feed established by the Agricultural Research Council (1980) or the 6% recommendation of Church *et al.* (1974), but for buffalo heifers that amount seems to be the limit to decrease feed intake.

After 12 weeks under each feeding regime, the daily live-weight gain of the buffalo given BD-SP (0.45 kg/d) tended to be higher than those fed BDO (0.35 kg/d). This gain was inversely related to total feed intake observed in buffaloes fed BDO (4.76 kg) and BD-SP (4.55 kg), to intake from concentrates (BDO: 1.54 kg vs BD-SP: 1.50 kg), and even to intake of digestible dry matter (BDO: 2.76 kg vs. BD-SP: 2.70). This phenomenon suggests that the addition of soybean pulp in feed can increase feed efficiency or feed conversion by increasing digestibility. Indeed, the digestibility of BD-SP (59.3%) was found to be higher than that of BDO (58.5%). Soy sauce is produced from soybeans fermented by yeast. The fermentation process is expected to increase the degradable fraction, so that the use of this feedstuff will increase the digestibility of roughage or straw fed to animals. Dietary supplementation by soybean pulp appears to have the ability to improve buffalo productivity, as shown by the feed conversion value of BD-SP (13.9) versus BDO (10.2).

Table 2. Daily live-weight gain, dry matter intake (DMI), feed and energy utilization, and methane production of buffalo heifers fed on BDO and BD-SP

Parameter	BDO		BD-SP		signif.
	Average	sd	Average	sd	
Daily live-weight gain	0.35	0.05	0.45	0.06	0.17
Dry matter intake, kg/d	4.76	0.39	4.55	0.60	0.33
Napier grass	3.22	0.18	3.05	0.29	0.14
Commercial conct.	1.54	0.23	1.11	0.25	0.01
Soybean pulp	-	-	0.39	0.09	0.01
Feed conversion	13.9	2.7	10.2	1.2	0.13
Dry matter digestibility, %	58.5	7.7	59.3	2.2	0.86
Energy intake, MJ/d					
Gross energy	70.1	5.7	68.9	9.1	0.14
Digestible energy	39.1	3.0	38.1	6.3	0.79
Metabolizable energy	28.3	3.1	28.2	3.8	0.95
Metabolizability, %	40.7	7.0	41.2	4.8	0.93
Methane production					
MJ/d	8.4	1.3	7.3	1.9	0.23
MJ/100 MJ GEI; MCR	12.0	1.4	10.5	1.7	0.13
g/kgDMI	31.8	3.8	28.7	4.7	0.20
g/kgLW Gain	443	109	295	72	0.001

Parallel with the finding in feed intake, the intakes of gross energy, digestible energy and metabolizable energy in the BDO group were higher than those in the BD-SP group. However, the contents of digestible energy

and metabolizable energy in BDO (DE: 8.21; ME: 5.93 MJ/kg DMI) were lower than those in BD-SP (DE: 8.37; ME: 6.20 MJ/kg DMI). The percentage of the GEI that was metabolized in BD-SP (41.2%) was higher than that in BDO (40.7%), whereas the GEI that was digested in BD-SP (55.2%) was lower than that in BDO (56.1%).

The higher value for metabolizable energy (%GEI) in BD-SP is caused by lower loss of energy in the form of methane. The results showed that MCR (MJCH₄/100 MJ GEI) from the BD-SP buffalo was lower than that of the BDO buffalo (10.5 vs. 12.0). The MCR value observed in this study was in the range of 2-12% (Czerkawski, 1969). The possible reasons for lower methane production in BD-SP than of BDO are (1) the improvement in feed quality by soybean pulp supplementation, and/or (2) the high content of fat in soybean pulp, which may catch free hydrogen atoms from fiber degradation and thereby reduce the formation of methane. Soy sauce is reported to contain 0.055% mono-unsaturated and 0.147% poly-unsaturated fatty acid (Asiamaya, 2003), which may reduce methane production (Nishida *et al.*, 1998).

The productivity of buffalo expressed as daily live-weight gain was higher in buffaloes receiving BD-SP than in those receiving BDO 0.45 vs. 0.35 kg). Methane production (g) per kgDMI in buffaloes fed BD-SP (28.7 g/kgDMI) was lower than that of BDO (31.8 g/kgDMI). Therefore, the ratio of methane emission per kilogram live weight gain was far lower in the BD-SP feeding, (295 gCH₄/kg), than in the BDO feeding (443 gCH₄/kg). The value for swamp buffalo in this study is higher than that of cattle fed Lucerne (*Medicago sativa*) hay and high grain *ad libitum* (127 gCH₄/kg live-weight gain) but better to that of cattle fed Rhodes grass (500 gCH₄/kg live-weight gain) in the comparative study by Kurihara *et al.* (1999). The differences between these results can be considered an effect of the better quality of temperate forages compared to tropical forages, especially in terms of fiber content and type of carbohydrate, both of which affect the methane production (Moe and Tyrell, 1979).

The methane production in this study was also compared to the predicted value calculated by equations formulated by Shibata *et al.* (1993) and by the equation of Kurihara *et al.* (1995). Shibata's equation is $Y = -17.766 + 42.793X - 0.849X^2$, while that formulated by Kurihara (1995) is $Y = 63.27 + 0.02678X$; where Y is the methane productions (L/d), and X is dry matter intake (kg/d for Shibata's and g/d for Kurihara's). Shibata's equation was established for thermoneutral conditions, while Kurihara's was established for hot conditions (30-32 °C) and would be applicable to Indonesian conditions. The results of methane production and the results of the prediction are presented in Table 3. The equations' predictions of methane production arrived at comparable values (Shibata's; BDO= 167 and BD-SP= 159 L/d; Kurihara's; BDO= 191 and BDSP= 185 L/d) and agreed

with the methane production from balance energy (BDO= 212 and BD-SP= 185 L/d) in this study. A similar tendency was found for MCR predictions (Shibata's; BDO= 9.4 and BD-SP= 9.2 L/d; Kurihara's; BDO= 10.8 and BDSP= 10.7) compared to the MCR (BDO= 12.0 and BD-SP= 10.5) in this study.

The agreement between predicted values and real values in this study is considered an effect of good feeding quality. The prediction by Kurihara *et al.* was closer than that of Shibata, probably because of the effect of ambient temperature, which received attention in their study but not in Shibata's. Kurihara *et al.* (1995) reported that methane production in hot conditions (30-32 °C) was approximately 110% of that in thermoneutral conditions (18 °C) at maintenance energy intake level.

Table 3. Methane production and the predicted value by Shibata's equation (1993) and Kurihara's prediction (1995) for methane production under hot condition

Treatments	Real	Predicted value	
		Shibata's	Kurihara's
Methane production (L/d)			
BDO	212	167	191
BD-SP	185	159	185
Methane Conversion Rate (MJ CH ₄ /100 MJ GEI)			
BDO	12.0	9.4	10.8
BD-SP	10.5	9.2	10.7

The results of this study showed that even for buffalo, the value of methane production could be maintained at as low a level as that of cattle when they were given a good diet (i.e. BD-SP). Also, this study showed that soy-pulp, the by-product of the soy sauce industry, which can be found in many South East Asian countries, could lead to a mitigation of methane, especially with consideration of the productivity.

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