FORAGE QUALITY AND FEED INTAKE EFFECT ON METHANE EMISSIONS FROM DAIRY FARMING

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Abstract. Based on the statistical data the situation of dairy farming in Latvia characterized by the feeding base and dry matter intake of dairy cows in herds and the effect on CH_4 emissions were evaluated. The dairy farming in Latvia is fragmented with the majority of farms having a small number of cows. 79.5 % of all farms have only 1-5 cows, but the number of big herds (over 50 cows) increases annually. The average milk yield in the monitored farms also increases annually, and reaches an average of 6584 kg per cow. Many opportunities exist to reduce enteric CH_4 and other GHG emissions per unit of product from ruminant livestock. To predict the potential for CH_4 reduction in dairy cattle production, the feeding strategy was analyzed. Optimized feeding of dairy cattle can reduce CH_4 emissions per 1 kg of the ECM from 2.5 % to 15 % without affecting milk production. CH_4 formation in the rumen can be minimized by the inclusion in the ration high-quality forage or concentrates, which are easily digestible. The fodder quality has also a significant effect on CH_4 production, and if the quality is poor, CH_4 production increases.

Keywords: enteric methane, dairy cattle, dry matter intake, forage.

Introduction

Interest in environmental matters has increased in recent years giving rise to discussions about how to reduce pollution from various sources. One harmful gas emitted into the atmosphere is methane (CH_4), which accounts for 18 % of greenhouse gases (GHG). Methane gas (CH_4) is a strong greenhouse gas and contributes significantly to global warming [1]. In nature, methane gas is produced by millions of micro-organisms, which are found in the rumen of ruminants as part of the digestive process. Methane gas also contributes to the energy losses – up to 10 % of energy, which is obtained from cows eating, are lost in this way. Globally, ruminants produce ≈ 80 million tons of CH_4 per year, creating a ≈ 33 % of anthropogenic emissions of CH_4. In ruminants for stomach (rumen), 100 g digestible cellulose produces 10 L of CO_2 and 3.5 L of CH_4 [2; 3]. A dairy cow can produce up to 650 L of methane per day, and most of it the animal emits by belching. A cow with productivity 9 000 kg of milk per year produces about 120-130 kg of methane per year. Formation of methane gas causes energy loss – an average of 6.5 % of gross energy provided by the food is lost in the form of methane gas. These losses can vary from 2 to 12 %. This is an opportunity to reduce contamination. In order to prevent a sharp increase in greenhouse gas it is necessary to comply with good agricultural practice including the optimization and control of protein in the daily ration according to the animal's needs. In particular stress should be on the improvement of forage – improving the forage quality and increasing feed intake [2-5].

The aim of the research was to investigate the forage quality and feed intake effect on enteric methane (CH_4) emissions from dairy farming. To achieve the goal of the research, the following tasks were defined.

1. To analyze dairy farming in Latvia.
2. To clarify the effect of dry matter intake (DMI) and forage quality on methane (CH_4) reduction options.

Materials and methods

The study material was statistical data about the situation of dairy farming in Latvia, as well as the data on dairy cow feeding and feeding methods in farms. Latvian and foreign literature compilation and analysis were used for data collection, evaluation and interpretation.

Results and discussion

The dairy farming in Latvia is fragmented and the majority of farms have a small number of cows. 79.5 % of all farms have only 1-5 cows, but the number of big herds increases annually. In holdings, able to provide efficient milk production, the number of cows has increased. Each year there is a steady increase in the number of cows that are kept in farms with above 50 cows (Table 1) [6]. As

well, increasing of the number of dairy cows on farms ranging from 6 cows is observed. A number of small farms have ceased operations in the dairy sector because of difficulties, such as the low price of milk and the requirement to provide high quality milk. The average milk yield in the monitored farms has increased from year to year, and reached an average of 6584 kg per cow [7; 8].

Table 1

Division of farms by number of dairy cows

Number of dairy cows in holdings	2012				2013			
	Number of dairy cows according to size of holdings		Dairy cows in group		Number of dairy cows according to size of holdings		Dairy cows in group	
	Number	%	Number	%	Number	%	Number	%
1	12 974	50.4	12 974	7.9	11 569	48.7	11 569	7.0
2	4 541	17.6	9 082	5.5	4 047	17.0	8 094	4.9
3-5	3 399	13.2	12 625	7.7	3 265	13.8	12 080	7.3
6-9	1 793	7.0	13 023	7.9	1 777	7.5	12 958	7.9
10-19	1 581	6.1	21 363	13.0	1 564	6.6	20 988	12.7
20-29	519	2.0	12 345	7.5	531	2.2	12 456	7.5
30-49	433	1.7	16 130	9.8	451	1.9	16 789	10.2
50-99	305	1.2	20 853	12.7	329	1.4	22 748	13.8
100-199	114	0.4	15 402	9.4	140	0.6	19 518	11.8
200-299	38	0.1	9 265	5.6	28	0.1	6830	4.1
≥300	43	0.2	21 555	13.1	43	0.2	20 981	12.7
Total	25 740	100	164 617	100	23 744	100	165 011	100

To predict the possibilities for methane reduction potential of a dairy cow herd, the strategy of dairy cow feeding was analyzed. One of the most important factors affecting the amount of produced methane gas of dairy cows is the amount of the food eaten. Encouraging a cow to eat large amounts of feed is the key to productive and efficient milk production. In Table 2 [1] the maximum total dry matter intake (DMI) (from roughage and grain mixture) that milking cows in mid-to-late lactation can eat is given. The table lists DMI as a % of body weight and in kg per day. A cow (550 kg live weight and 30 kg milk yield per day) can eat 3.7 % DM of its body weight daily that is about 20.4 kg. A bigger cow (650 kg) at the same milk yield can eat only 3.4 % DM of her weight (i.e., 22.1 kg per day). Bigger cows at higher milk yield can eat more feed DM.

For every 2 kg of milk yield a cow has to eat at least 1 kg of dry matter. If the feed dry matter digestibility decreases from 75 % to 55 %, then dry matter intake of a dairy cow drops from 4.3 kg to 2.5 kg per 100 kg of live weight. On average, good hay provides 12-14 kg of dry matter, but excellent quality of silage, along with the cow genetics, can provide a higher amount of dry matter – 15-16 kg. The dry matter intake (DMI) ability of a medium quality fodder is 1.8-2.2 % of live weight per day [9].

Table 2

Dry matter intake by cows in mid to late lactation, % per body weight and kg per day

Milk yield, kg	Cow body weight, kg					
	450		550		650	
	%	kg	%	kg	%	kg
10	2.6	11.7	2.3	12.7	2.1	13.7
20	3.4	15.3	3.0	16.5	2.8	18.2
30	4.2	18.9	3.7	20.4	3.4	22.1
40	5.0	22.5	4.3	23.7	3.8	24.7
50	5.6	25.2	5.0	27.5	4.4	28.6

Roughages are feeds high in fiber (e.g., hay, haylage and corn silage). The DMI from roughage determines the amount and type of the grain required in the ration. Milk cows can consume 1.8 to

2.2 % of body weight daily as DM from average quality dry roughage. Roughage quality is partly determined by fiber levels. Fiber content increases as the forage crop matures. High fiber forage has lower palatability, reduced protein levels, and is less digestible than high quality material. Undigested feed cannot pass out of the rumen. The cow cannot consume more feed until the feed in the rumen is digested. High fiber forages reduce DMI. A cow can eat 3 % of body weight as DM from excellent hay but only 1.5 % from poor hay, Table 3 [1].

Table 3

Maximum DMI, kg of legume hay or haylage of different quality

Hay crop quality	Hay crop DMI, kg			
	DMI as a % of body weight	Cow body weight, kg		
		400	500	600
Excellent	3.0	12.0	15.0	18.0
Good	2.5	10.0	12.5	15.0
Poor	1.5	6.0	7.5	9.0

The amount of produced methane gas increases by increasing the feed intake. It should, however, be noted that although the total amount of the produced methane gas increases, the energy, used by the cow and lost in the form of methane gas, decreases. As a result of the increase in dry matter intake the feed energy efficiency is increasing and methane gas per liter of produced milk is reduced [10].

The optimal proportion of forage and concentrates in ration positively affects feed dry matter intake, and for dairy cows it should be 3: 1-2. In Latvia, in most farms the concentrated feed proportion varies from 30 to 40 %, while the proportion of forage is 55-65 % of total energy. By improving the dairy cows' genetic quality and herd management practice, cows average milk yield increases, so the total volume of milk produced in Latvia also continues to grow. It should be noted that the increase in the productivity of cows leads to the improvement of feed rations with increased amount of easily digestible high energy concentrated feed [9].

This is partly due to the lower crude fiber content and faster feed movement through the digestive tract. The farms in which the herd productivity exceeds 8000 kg of milk per cow in lactation, but for some cows in early lactation it reaches 40-50 kg per day, are faced with significantly higher amounts of concentrated feed and a lower proportion of fodder; see Table 4 [9]. In this situation, the cows have risks of digestive or other physiological disorders (rumen acidity increases, loss of appetite and subsequent loss of productivity, a reduction in the fat content of milk, etc.).

Table 4

Amount of necessary concentrated feed, kg per cow depending on the quality of the grass feed (animal weight – 600 kg, milk fat – 4.0 %)

Grass feed quality	Daily milk yield, kg				
	10	20	30	40	50
Bad	4.90	9.10	13.30	-	-
Average	1.50	5.70	9.90	14.10	-
High	-	2.10	6.20	10.30	14.60

With regard to the reduction of methane formation, the feeding ration with 40 % or more of the concentrated feed shows good results calculated on the basis of the dry matter. On the issue of the critical level of concentrated feed, there have not been a lot of different opinions of scientists. According to the scientists of the Babcock Institute for International Dairy Research and Development, in their ration calculations the permitted proportion of fodder and concentrated feed is 45-50 and 55-60 %, respectively, for cows with average milk yield 40-50 kg per day. The researchers of Latvia Scientific Institute "Sigra", with reference to the requirements of the European Union control institutions, suggest the relationship of 50 % and 50 % [11; 12].

During the summer, the quantity of concentrated feed in the ration should not exceed 20 % of the total energy needs. This means that for a cow with milk yield of 20 kg and 30 kg, while staying in the pasture, 4 and 5 kg, respectively, of concentrated feed per day is sufficient, but for more productive cows this amount should be increased to 6 kg or more per day. A cow of 500 to 600 kg in pasture can

intake up to 100 kg of good quality grass (the average of 70 to 90 kg of grass), which accounts for 11-14 kg of grass dry matter. Adding grain to the feed ration increases the starch content and reduces the amount of crude fiber, reducing rumen pH and promotes the production of propionate in the rumen. The maximum amount of concentrates is defined at 400 grams per kg of milk, 3.0-3.2 % of the cow live weight and 65 % of the feed ration energy value [9; 12].

The feeding pattern of dairy cows depends on the forage preparation traditions and techniques in a farm. In herds with 1-5 cows the hay and root feeding type predominates, in herds with 5-20 cows – the mixed feed type with greater variation, but in herds with more than 20 cows – the silage feeding type. For animals with less than 7000 kg milk yield the common practice is grazing in pastures in summer time, which is the optimal eating model of more than 100 kg grass per day. Latvian Brown cows at pasture are able to eat 82-90 kg of grass, which accounts for 14.8-16.2 kg of dry matter, or 2.95-3.24 % of the live weight of the cow. In Latvian conditions, depending on the pasture yield and cow productivity, the average dry matter intake with grass is 12-16 kg [12].

Forage quality significantly affects methane production. Fodder quality has a significant effect on methane production, and if the feed quality is poor, the production of methane gas is increasing. This is the main cause of the loss of cow energy and, if it could be avoided, it would lead to an increase in the milk yield. By improving the forage quality it is possible to increase the dry matter intake (DMI) ability and reduce its residence time in the rumen, thereby promoting a more efficient use of energy in the outermost feed digestion processes and reducing the proportion of energy that is converted to methane gas. The feed milling and granulation can reduce methane emissions by 40 %, but practicing these types of feed preparation should be done to pre-assess the economic benefits [2; 3; 10].

An effective way to reduce methane formation in the rumen is fat additives into the feed ration, reducing CH4 production up to 37 %. For reduction of methane gas production relatively new features have been investigated, for example, feed additives, which have the ability to inhibit the production of methane. Among them there are some organic acids and plant extracts (e.g., tannins, saponins and oils). This feeding strategy reduces CH_4 thanks to the rumen fermentation process. Better nutrition strategy leads to decreasing of CH_4 production by > 35 % with increasing the ration efficiency. Therefore, the reduction of CH_4 gas production makes both economic and environmental benefits [2-5].

Conclusions

1. The Latvian dairy farming is fragmented and the majority of farms have a small number of cows. 79.5 % of all farms have only 1-5 cows, but the number of big herds increases annually. Each year there is a steady increase in the number of farms keeping above 50 cows.
2. One of the most important factors affecting the amount of the produced methane gas of dairy cows is the amount of eaten food. The amount of the produced methane gas increases by increasing the feed intake. A cow weighing 550 kg with 30 kg milk yield can eat 3.7 % DM of her body weight or about 20.4 kg. A bigger cow (650 kg) with the same milk yield can eat only 3.4 % DM of her weight or 22.1 kg per day.
3. Forage quality significantly affects methane production. By improving the forage quality it is possible to increase the dry matter intake (DMI) ability, increase the milk yield and reduce the proportion of energy that is converted to methane gas.
4. Milk cows can consume 1.8 to 2.2 % of body weight daily as DM from average quality dry roughage. High fiber forages reduce DMI. A cow can eat 3 % DM of body weight from excellent hay but only 1.5 % from poor hay.
5. An effective way to reduce methane formation in the rumen is additives of organic acids and plant extracts in the feed ration. Fat additives into the feed ration can reduce CH_4 production up to 37 %.

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